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Editorial

Special Issue on The Thirty Meter Telescope – Observatory GenNext

Optical Astronomy is as old as human life itself since the human eye can also function as a telescope, a detector and an analyser. However, the importance, potential, and power of optical telescopes in discovering and deciphering the secrets of celestial objects was realised only about four centuries ago, when the Italian Astronomer Galileo Galilei used an optical telescope with a small aperture and turned it towards the sky and began analysing visual observations of planets such as Venus, Jupiter, Saturn, etc. These observations have revolutionized our ancient thinking that the Earth is at the centre of the Universe. In fact, today we know that the centre of the Universe is not even in the solar system. This knowledge has been facilitated through observations with both ground- and space-based telescopes and their studied interpretations. Since the invention of the telescope therefore, astronomers have augmented mankind's intellectual horizons, transporting our understanding of the Earth from being a nonmoving centre of the Universe to one of several small planets around a typical small star in the outskirts of just one of billions of galaxies, all evolving in an expanding Universe in which planets are common.

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. Today, technological developments in both electronics and computers have enabled the manufacturing of extremely large-sized optical telescopes to be economical and feasible. Globally, plans are underway to build three mega-sized (25 to 40 m aperture) ground-based modern optical and near infrared optical telescopes. These projects would be determined on the success of the present day large-sized (10 to 16 m aperture) telescopes, available cutting edge of technology, adequate finance and manpower, and the quest for further understanding of fundamental issues in the Universe such as dark energy and extra terrestrial life, etc.

Understandably, such projects are beyond the capabilities of any one nation. For example, the Giant Magellan Telescope, $\sim$25 m in size, which is led by a group of Universities in USA, Australia and South Korea and the European-Extremely Large Telescope, $\sim$39 m in size led by 14 European countries and Brazil. The Thirty Meter Telescope (TMT) Project is led by a group of US institutions namely, California Institute of Technology (CalTech); University of California and University of Yale. Other participating nations in the TMT Project are Canada, China, Japan and India. The TMT is a global effort in which all partners contribute to the design, construction, technology development, and scientific use of the Observatory. The TMT, like all telescopes with more than one-meter aperture size, is basically a reflecting telescope. But it will comprise of 492 hexagonal mirror segments, each

1.44 m in size and is planned for installation on the summit of Mauna Kea located in the island of Hawaii in the United States. Plate 3 (see page 80) shows an aerial picture of the TMT site on Mauna Kea alongwith the Canada–France–Hawaii Telescope (CFHT), and the Japanese Subaru and Keck Telescopes. The estimated cost of the TMT project is $\sim$ \$1.4 billion. With TMT, it will be possible to study the Universe as never before and find answers to many of the grand challenges of Science.

This special issue of the *Journal of Astrophysics and Astronomy* (Vol. 34, No. 2, June 2013) published by the **Indian Academy of Sciences**, aims to inform the learned Indian scientific community about India's participation in this multinational mega project and highlight its important technical aspects. The article by **Gary H. Sanders**, Project Manager of TMT elaborates on the issues concerning participation of institutions and countries, the technological challenges present in the project, the key science programmes which TMT will enable as also the unprecedented gains in both light gathering power and angular resolution imaging capabilities of the TMT.

India's participation is at about a 10% ($\sim$140 million USD) level and will be jointly funded by the Department of Science & Technology (DST) and Department of Atomic Energy (DAE), Government of India. The Indian activities are being coordinated by the India TMT Coordination Centre (ITCC) located in the Indian Institute of Astrophysics, Bengaluru. **B. Eswar Reddy**, Director of this Centre, in his article shares salient details of the scientific justification and status of the technical participation of Indian astronomers as well as of Indian companies. India's proud participation in the TMT project is recognition of its growing stature in global multi-wavelength observational astronomy.

It is well known that a telescope collects only photons. These photons need to be analysed to carry out front-line science. Back-end instruments mounted on a telescope are therefore extremely valuable. To realize its full scientific potential, TMT will be equipped with a suite of first generation instruments. These details find description in the article written by **Luc Simard** who heads the TMT instrumentation group. This article describes the capabilities and technical details of the first light science instruments. It also informs the reader about a diverse set of new instruments, now under study, that will bring additional workhorse capabilities to serve the scientific interests of a wider user base and also offer a wide range of opportunities to all TMT partners. Despite its extremely large size, the TMT will be a ground-based telescope. As a consequence, images of celestial objects formed by the TMT will be blurred by turbulences present in the Earth's atmosphere. These distortions can now be countered using a technique called Adaptive Optics (AO). The article by **Brent Lee Ellerbroek**, an expert in the field, provides a status on the TMT adaptive optics programme. The Adaptive Optics system uses a bright point source of light in the sky as a reference beacon to measure turbulences produced by the Earth's atmosphere. For TMT, China is to provide the *Laser Guide Star Facility* which will act as a bright star in the sky. The first light AO facility for TMT consists of the narrow field infra-red AO system and the associated Laser Guide Star Facility. This instrument is capable of providing diffraction-limited images in J, H and K photometric bands over 17–30 arc sec diameter fields. Progress in AO components prototyping, control algorithm development and system performance analyses are also presented in this article by Ellerbroek.

Considering the fact that vital diagnostics are present in the domain of optical astronomy, TMT can provide valuable complementary optical follow-up observations of extragalactic radio observations carried out by the Indian Giant Meter Radio Telescope built and operated by NCRA-TIFR. **C. H. Ishwara-Chandra** articulates the value of such multi-wavelength observations in his article. Recent studies have proved beyond doubt that observations at optical wavelengths are essential to characterize and understand the sources detected in any other band of electromagnetic spectrum. Radio sources located beyond red shift of 5 require deep optical and near-IR observations with the capabilities of TMT. This aspect has been emphasized taking a few science cases in radio astronomy. **Sujan Sengupta** delineates the importance of polarimetric observations taken with TMT in the case of exo-planetary systems discovered recently. The article suggests that even a low spectral resolution spectro polarimeter with a capability to detect linear polarization of 0.5–1% at the TMT would immensely help in understanding the atmosphere, specially the cloud chemistry of the self-luminous and resolved exo-planets. The contribution of TMT, equipped with modern first generation back-end instruments, towards the understanding of front-line research problems in the area of the evolution of massive stars and high-red shift Universe using core-collapse supernovae and gamma-ray bursts have been effectively summarized by **S. B. Pandey**. The understanding of mechanisms and progenitors of these energetic events by TMT has been highlighted against the background of existing information on these objects. The TMT Infra-Red Guide Star Catalog (TMT-IRGSC) consists of stars as faint as J $\sim$ 22 mag covering the entire TMT observable sky from $+90$ to -45 degrees in declination and are required for efficient planning and observing for this project. This important work is being carried out under the leadership of Indian astronomers. The methodology and technique used in generating this valuable catalog are detailed in the article by **Smitha Subramanian *et al.*** which provides the status of this work.

India's participation in TMT will enable the Indian astronomical community to be involved with very exciting and pioneering astronomical research ranging from the study of exo-planets, to the origin and evolution of galaxies and black holes, to epochs close to the very origin of the Universe where recently high energy laboratory experiments were being carried out in Europe though on a small scale. Our involvement in TMT will catapult the Indian astronomical community into the forefront of optical and near-infrared astronomy and several key technologies related to the latest segmented mirror telescope such as edge sensor, segment support assembly, etc. would be transferred to India. This invaluable experience will help Indian industries and astronomers to develop our own 10-m or a larger sized segmented mirror telescope to be located on Indian soil. Besides astronomy, TMT will contribute to engineering and technology, international relations and workforce development. Given our strong theoretical background, strong quest for knowledge and our huge human resource along with the existing and upcoming multi-wavelength ground- and space-based observing facilities and international collaboration, India can certainly contribute significantly to the field of astronomy while advancing the country's indigenous technology development and growth of human resources.

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Ram Sagar
Chief Editor

Plate 1. An artist's rendering of the TMT observatory building (*reproduced from www.tmt.org*).

Plate 2. A closer view of the TMT building showing the 30 m diameter primary mirror made of 492 hexagonal segments (*reproduced from www.tmt.org*).

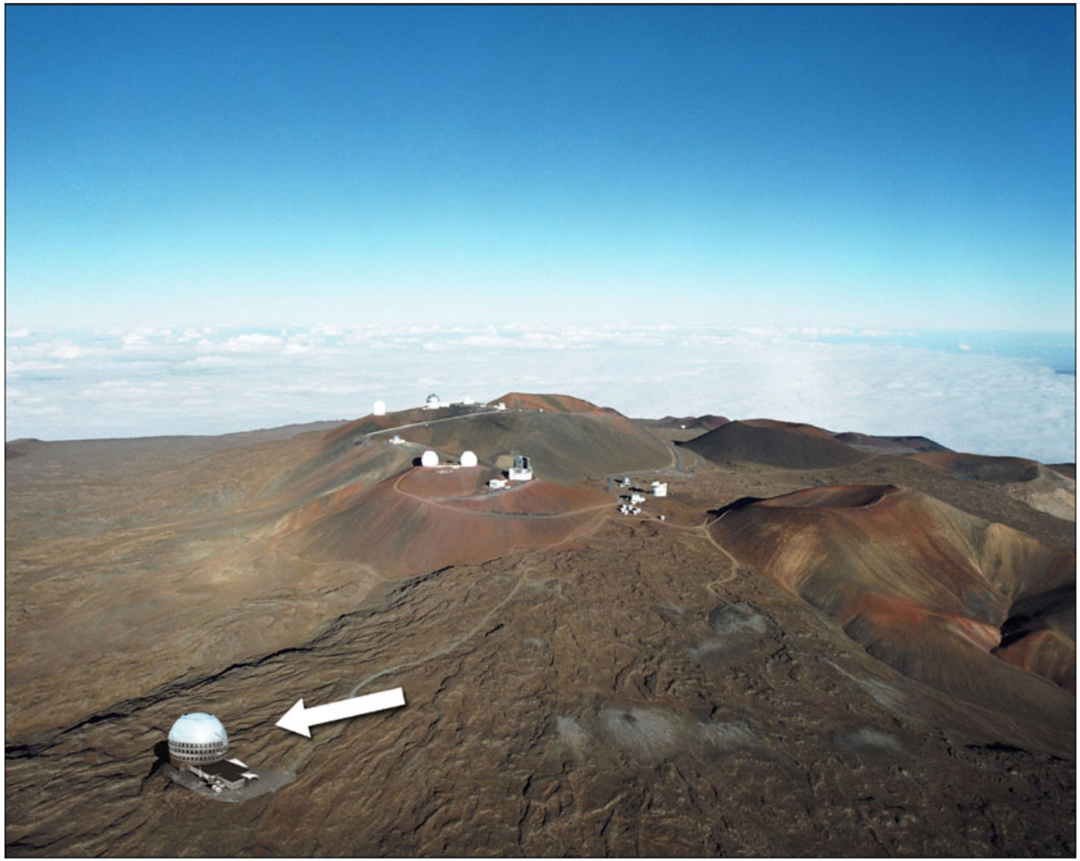

Plate 3. An aerial view of the TMT site (follow arrow) on Mauna Kea, Hawaii in the United States. Also seen are the Canada–France–Hawaii Telescope (CFHT) and the Japanese Subaru and Keck Telescopes (*reproduced from www.tmt.org*).