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TIFR/UPSO 3-metre telescope project

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Abstract. A 3-metre telescope is being proposed to be set up at Devasthal near NainiTal, jointly by UPSO NainiTal and TIFR, Mumbai. The telescope specifications, building and dome requirements, back-end instruments, budgetary requirements and project administration plan have been outlined in this note.

Key words: telescope, astronomical site, focal-plane instruments

1. Introduction

UPSO and TIFR are proposing a 3-metre optical telescope to be set up jointly at Devasthal near NainiTal. For the last fifteen years or so, UPSO had been struggling to get a large telescope. As the 1-metre telescope of UPSO is more than 25 years old, the need for a larger observational facility has been strongly felt by the astronomers of the Observatory. In a meeting held by DST last year, regarding a 2.5-metre telescope for UPSO, it was suggested by DST that UPSO should undertake such a project in collaboration with other central institutes. Likewise, astronomers at TIFR, were anxious to have access to a 2-metre class optical telescope to complement the research being carried out at other wavelengths., in particular with GMRT. Therefore the two institutes decided to moot a proposal for setting a large telescope jointly. After extensive deliberations concerning availability, cost and transport etc. a size of 3 metre was arrived at.

A 3-metre size modern optical telescope will go a long way in filling a major imbalance and a serious gap in the basic capabilities of the two Institutes in observational astronomy. Such an instrument will play a major role in ensuring the long-term survival and competitiveness of UPSO and TIFR astronomers. The proposal has been accepted in principle by the TIFR director and the Secretary, Department of Science and Technology, U.P. Government. Already a provision for a token amount for the project has been made by TIFR. The telescope is proposed to be set up on cost sharing basis, both the institutes having agreed to bear the cost equally.

2. The site at Devasthal

The importance of good astronomical sites for putting up new telescopes has been realised more and more in recent years. UPSO had conducted a site survey programme for identifying a suitable site for its future observing facilities in hills of Kumaon and Garhwal in 80s. After a survey extending for about a decade, a suitable site, Devasthal has been identified. Devasthal is about 50 kms from NainiTal, is situated at an altitude of 2420 metres and is logistically well placed. There is already a metalled road upto 2 kms from the site and plenty of flat land is available for establishing the telescope and associated facilities. Devasthal has more than 200 clear nights, most of them being photometric. The skies are dark with sky brightness of the order of 21 mag/arc sec. sq in the V band, the seeing is of the order of one arc sec, water and electricity are available nearby and the area is only thinly populated (about 50 per sq. km in a radius of 5 kms) with no major towns nearby. As you will hear in a later talk by Prof. Ram Sagar, the site is being further characterized quantitatively. Already the site acquisition process is in progress.

3. The 3-metre telescope

The telescope will be a 3-metre Ritchey-Chretien (RC) System. It will have a Cassegrain and Nasmyth focii. The focal length of the primary mirror determines the size of the telescope tube and hence the size of the dome and building. By building the primary mirror of smaller f-ratio, there is considerable cost savings. However, small f-ratios are difficult to fabricate. Today's technology permits to make f-ratios as small as 1.5. Considering various factors, a f/2 primary has been proposed. Other important parameter is the thickness of the primary mirror. By making light weight primaries, there is reduction in total weight of the telescope. A diameter to thickness ratio of 12 for the primary mirror has been chosen. The mirrors will be fabricated from a zero-coefficient expansion glass such as Zerodur or ULE. The telescope optics design will provide an excellent image quality. The on-axis 80 percent encircled energy will be confined in a diameter of less than 0.4 arc-second and for off-axis upto a radius of 20 arc-minute will be confined in a diameter of less than 0.6 arc-second using proper correctors.

The final focus of the telescope will be f/10. This focal ratio has been chosen keeping in view the size of the secondary. Smaller f-ratios will require a larger secondary thus causing more obscuration of the light falling on the primary resulting in loss of limiting magnitude. The RC focus will have a corrected field of view of half a degree. The position of final focus will be 1.5 metre behind the primary. Initially only Cassegrain focus will be provided. Provision will be made to have a Nasmyth focus also. The Nasmyth focus will primarily be used for such instruments which are too heavy to be put on the Cassegrain focus.

The telescope will have an alt-azimuth mounting. This type of mounting has become preferred mode of mount over conventional equatorial mounting. The alt-azimuth mounting is much simpler from mechanical design point of view and is easier to fabricate. However, in such type of mounting both the azimuth and altitude axes have to be rotated with non-uniform speeds. Todays computer controlled interfacing easily permits to surmount this problem. The telescope will operate at all points upto the horizon and meet its optical and mechanical performance specifications. The zenith blind spot will be less than 2 degrees. As the field rotates in case of alt-azimuth mounting at all focii, suitable image derotators will be provided at Cassegrain and Nasmyth focii. Both the focii will have suitable acquisition and guidance units so that offset guiding can be automatically done while observing. A tracking accuracy of 0.2"/hour will be achieved.

4. Telescope building and dome

The telescope will be housed in a building having 16-meter diameter dome. The telescope will be mounted on a 4.0 metre diameter R.C.C. pier, the foundation of which is completely isolated from the building and the dome. The dome will be hemispherical and will have a 2.0 metre high bottom cylindrical portion. The dome will have a 4.5-metre wide opening for unobstructed telescope viewing. A 4-metre by 4-metre hatch will be provided to take the mirror down for aluminising. A 2-ton lift will also be provided. For servicing heavy parts of the telescope, a heavy duty crane with a suitable capacity and with a reach upto the centre of the hatch at 5.5 metre radius will be provided.

The main floor will be at 18.5 metre above ground level. The height of the telescope axis from the ground will be 23.0 metres. The telescope building will have three floors besides the main telescope floor: ground floor at +0.5 metre, first floor at +6.5 metres and second floor at +10.0 metres from the ground level. These floors will accommodate a control room for controlling the telescope and the instruments, a computer room, a library, a recreation room, an electronics laboratory, an optics laboratory and office rooms.

The telescope building will have a 10-metre extension on one side to house the aluminising Unit. This extension will be 6.5 metre high from the ground and will be in front of the hatch area so that the primary mirror can be easily transported to the aluminising chamber.

5. Instrumentation

Photometer and spectrograph are the two bare minimum focal plane instruments required for any optical telescope. In order to use the telescope optimally, a Faint Object Spectrograph and Camera (FOSC), a CCD imaging camera, a near IR imaging camera and a high resolution Echelle spectrograph have been proposed.

FOSC is a focal reducer instrument, which means by using a collimator and a camera, one can reduce the effective focal length of the telescope. The basic advantage is two fold: a) a larger field can be covered using a given detector and b) dispersive elements can be inserted between the collimator and the camera. Thus the instrument can function in both imaging mode and spectrographic mode and one can shift between the two modes in minutes. The proposed FOSC will render the f/10 output beam of the telescope to f/3 and will give a corrected field of 10'.

Direct imaging in broad and narrow photometric bands will be one of the key requirements of the astronomers. For this work, the CCD is the detector of choice. To utilise the full field available at the FOSC, a CCD system of 2048×2048 having 15 micron square pixels will be ideally suited.

For observing in near infrared a HgCdTe detector will be used. This type of detector has sensitivity upto 2.5μ. Thus observations in JHK photometric bands will become possible. The detector will have 1024×1024 pixels having 18.5 micron square pixels.

For high resolution spectroscopy, a cross-dispersed echelle spectrograph having a resolving power of 60000 is being proposed. The spectrograph is required to have the highest practical mechanical and thermal rigidity. Therefore, the spectrograph will be located in a room having thermal control and high quality mechanical support. The light from the telescope will be fed via an optical fibre to the spectrograph.

6. Budgetary requirements

The total cost of the 3-metre telescope project has been estimated to be Rs. 30 crores. The telescope itself will cost about 15 crores, the proposed instruments about 5 crores, the buildings and dome about 3 crores, aluminising facility about 1 crore, the site development and roads about 1 crore and infrastructure, manpower and project expenses about 5 crores.

7. Project organisation and execution

The 3-metre telescope is to be set up jointly by TIFR and UPSO. The engineering and managerial experience is of the TIFR personnel who had participated in the completion of GMRT project will be extensively utilized here. The major involvement of UPSO will be towards the development of infrastructure and the general management of the site (Devasthal) during and after the installation of the telescope, as well as providing a large fraction of the manpower for operating the telescope.

For the timely execution of the project, the project organisation should have sufficient powers of decision making, appointment of project staff, approving of the contracts and purchases of components and equipments. To carry through the project a Project Director will have to be appointed who will be the overall in-charge of the project and will be responsible for its completion. The Project Director will be delegated the administrative and financial powers for the day to day functioning of the project.

To implement the project, we will adopt the following sequence of steps:

(i) Appointment of the Project Director

(ii) Finalisation of the specification of the telescope and their focal plane instruments.

(iii) Identification of suppliers of the telescope.

(iv) Completion of the civil works, including the dome.

(v) Procurement of the telescope.

(vi) Design and procurement of focal-plane instruments and associated control and data acquisition systems.

(vii) Installation of the telescope and associated instruments.

(viii) Testing and calibration of the telescope and the instruments.

The whole project is likely to be completed in a span of 4 years.