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A brief report on the Infrared Telescope at Gurushikhar, Mt. Abu

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1. Introduction

Realising the need for a dedicated infrared telescope for studies relating to star formation and dust enshrouded astrophysical objects, in which extinction is severe at optical wavelengths, Physical Research Laboratory took up an ambitious project of building a 1.22 m (48 inch) telescope that could exploit the atmospheric windows in the near - and mid - infrared up to 10 microns. The site for such an endeavour should be free from dust and water vapour. After looking into various sites available in the country it was decided to set up an observatory at Gurushikhar, Mt. Abu in Rajasthan (Fig.1). Gurushikhar is located 225 km north of Ahmedabad at an altitude of ~ 1700 meters and offers more than 200 clear nights per year. Many times the observatory is above the inversion layer. The preciptable water vapour is usually around 1-2 mm in winter, which makes Gurushikhar a good observing site for infrared window. In addition Mt. Abu is logistically a well suited site and is easily accessible from Ahmedabad and New Delhi.

The first Gurushikhar Infrared Telscope (GIRT) has been successfully put into operation during December 1994 (Fig.2) and seeing-limited images have been recorded. At present some finer adjustments are being made.

Several centres in the Department of Space, the Indian Institute of Astrophysics at Bangalore and other laboratories have extended their co-operation in completing this project. Initial work on the optics of GIRT was done at the Indian Institute of Astrophysics. The final figuring was done by Sinden Optical Engineering Company, U.K. to bring it to its present condition. Further, Prof. Willstrop of Institute of Astronomy, Cambridge, U.K., had been very helpful at various stages of testing and evaluating the mirror. The mechanical systems regarding the telescope mounts were made by SHAR while the dome was constructed by Prabhakar Products, Madras. The telescope control systems were developed at ISTRAC, Bangalore.

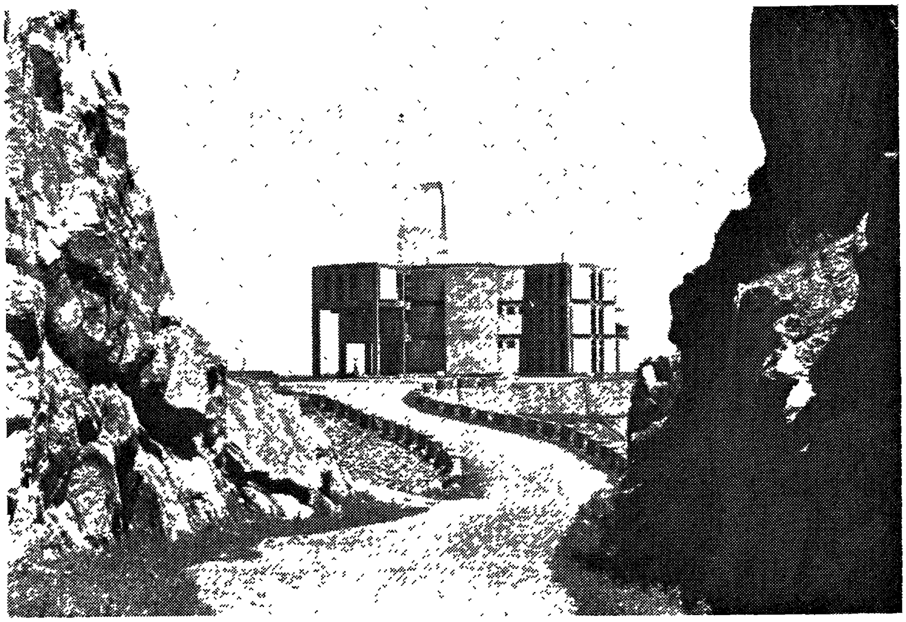

Figure 1. Infrared observatory at Gurushikhar, Mt Abu.

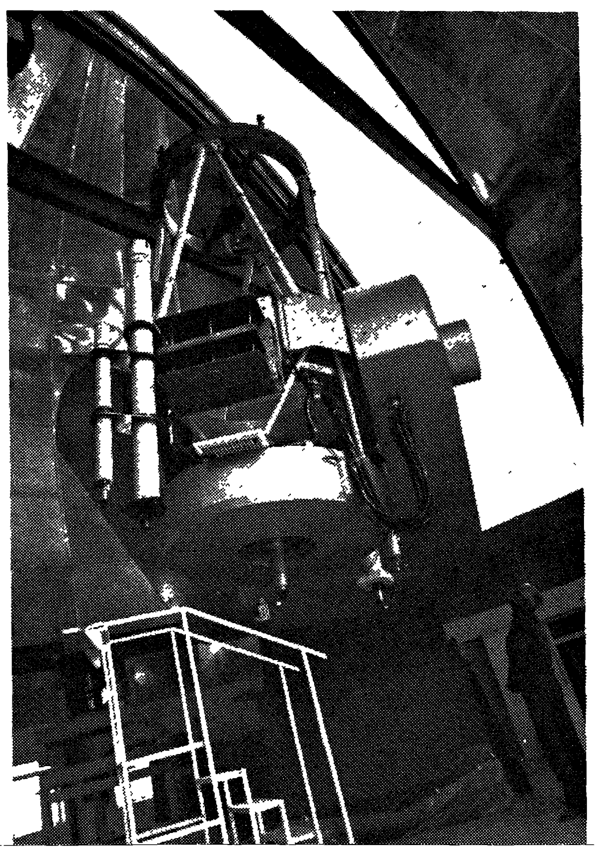

Figure 2. 1.2m Infrared telescope, Gurushikhar, Mt Abu.

The GIRT :

The telescope is mainly designed for infrared observations, however, the surface accuracy of all the optical components has been achieved for observations at 5000 Å. Hence the telescope can also be used for optical observations. The primary mirror has an aperture of 1.22 m with f/3 beam. The surface accuracy of the primary mirror is $\lambda/10$ (at Hg green line) and specified for 90% light in 0.5 arcsec. The entire telescope can be nodded with a frequency of 1 Hz for chopping the signal. Two secondary mirrors have been provided for observations at the Cassegrain focus. One of them is a vibrating secondary mirror with f/45 beam. The vibration is essential to chop the signal so that the fainter objects can be detected. This mirror is undersized for infrared observations. The secondary mirror has f/13 beam, operates in a non-vibrating mode and is used for observations at the Cassegrain focus. At the centre of this mirror, a small plane mirror has been attached with a small tilt with respect to the optical axis of the primary mirror to deflect away the IR radiations received from the Cassegrain hole of the primary mirror. Provision is also made for a coude system (f/45 beam) so that observations with heavy instruments can be made.

The telescope is fully computer-controlled and the images can be acquired within an accuracy of 5 arcsec.

Main focal plane instruments at the observatory :

(a) High speed near infrared photometer for lunar occultations :

A high speed near Infrared photometer has been developed at PRL over the last few years for observing lunar occultations with the aim of achieving milliarcsecond levels of resolution on bright IR sources. The occultation event is typically over in a few hundred milliseconds which dictates that data be sampled at intervals of about a millisecond in order to properly record the Fresnel fringes. The detector and preamplifier circuits have to be fast enough to record data at this rate. The occultation photometer consists of :

1) an optical and mechanical system in which the f/13 beam from the telescope is reflected into the side-looking dewar housing the liquid nitrogen-cooled InSb detector system. A field eyepiece for star acquisition and a second level precise star centering device are included. The beam is folded by a 45° mirror mounted on a vibrator which is used for conventional (slow) photometry.

2) the liquid nitrogen-cooled dewar has filter *J*, (1.2 micron), *H* (1.65 micron), *K* (2.2 micron), *L* (3.6 micron), *M* (4.8 micron) and three diaphragms with fields of view of 6.5 arcsec, 13 arcsec and 26 arcsec on the sky of the f/13 Cassegrain focus of the 1.2 m Gurushikhar telescope.

3) the preamplifier output is fed to a data acquisition and control system (model 575). This system has a 16 bit A/D converter and interface to a PC/AT so that data is directly

recorded on a PC and immediately displayed after the occultation. The control system can be used to trigger the data acquisition process at a preset time. Normally the data acquisition begins 15 sec before the predicted time and continues for 15 sec after the predicted time to take into account the uncertainties in time prediction of occultation of sources with co-ordinates not precisely known.

Two lunar occultations (sources IRC − 10557 and IRC + 10024) have been successfully recorded in the *K* band, on 7 and 12 Dec. 1994 using the GIRT. The observations of the first source (see Fig.3) were made during the day time ($17^h\,37^m\,15^s$).

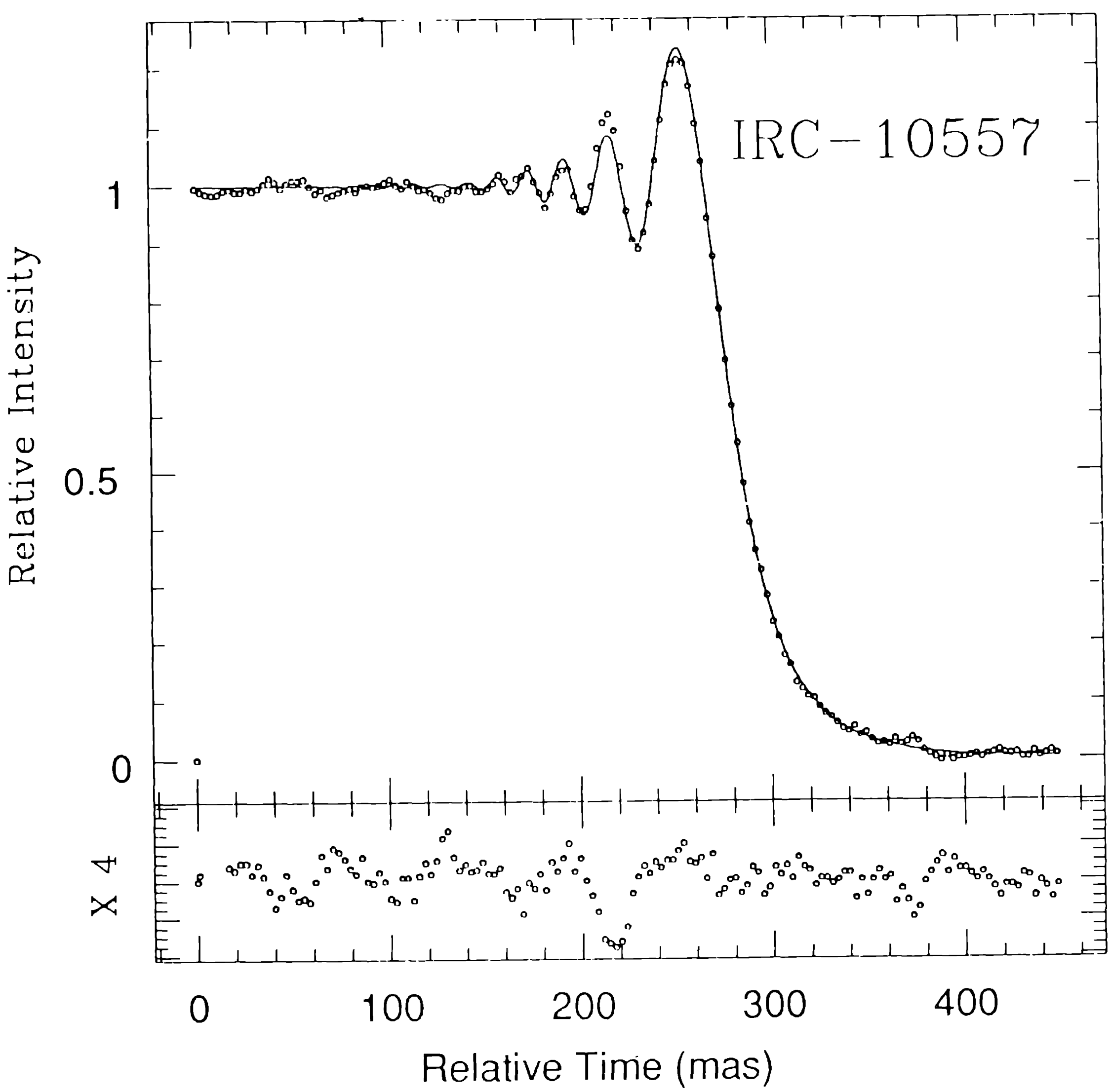

Figure 3. Lunar occultation light curve of IRC−10557 recorded at the 1.2m telescope at Gurushikhar in the *K* band (2.2 micron).

(b) Imaging Fabry-Perot spectrometer (IFPS) :

A seeing-limited, imaging Fabry-Perot Spectrometer (IFPS) has been designed and constructed for velocity field mapping in extended astronomical sources like gaseous nebulae, galaxies, as well as nebulosities surrounding certain stars. The dispersive element consists of a piezo-scanned servo-controlled Fabry-Perot etalon which maintains stability and parallelism to better than lambda/200. Several etalons are available for different emission-line widths ranging from 3–22 Å in the wavelength range 4500 to 7000 Å. Velocity resolutions of 6–50km/s are possible. Scanning provides a line profile at every spatial point (seeing-limited). Complete coverage of the extended object is possible over a field of view and about 4 arcmin (for the 1.2 Gurushikhar telescope) and about 2 arcmin for the 2.3 Vainu Bappu Telescope). The detector used in an Imaging photon-counting Detector (IPD) having a 520 cathode (Quantum efficiency of 18% @ 4500 Å), a stack of 3 microchannel plates and a resistive anode readout, has nominal pixel size of ~ 60 m corresponding to about 300 x 300 pixels overall (18 mm dia). The dark noise is ~ 10^{-3} counts/s/pixel at 20°C. Maximum count rate of IPD is 2 x 10^5 count/s on the entire detector and 100 count/s on one pixel. A provision for cooling the IPD has also been made. The IFPS has a facility of off-set guiding with a CCD/Image intensifier so as to accommodate long integration times (> 30 mts). Several observations have already been made using the IFPS (at VBT and recently at GIRT) on HII regions, planetary nebulae and a few galaxies in several emission lines.

(c) Optical and near infrared CCD Cameras :

A CCD camera in the optical region has been developed. The CCD has 386 x 576 detectors each of 22 micron size and has a response up to 1 micron. An image processing system that can be integrated with a PC has also been designed and developed. Several special softwares to go with the system have been written. Observations of Comet Austin and some globular clusters have been made.

An infrared camera with 256 x 256 HgCdTe detector array is being procured to carry out photometric, polarimetric and spectroscopic observations.

(d) Optical and near infrared polarimeters :

In addition to the existing optical photopolarimeter, we have recently designed and developed a near infrared polarimeter. It has an InSb detector operated at liquid nitrogen temperature. Observations in the *K* band can be made up to a magnitude of 7.5 on a one meter telescope. The polarimeter is computer-controlled with an online data processing facility. With the already existing visual band polarimeter, we can now measure polarization from *U* band to *L* bands.

An imaging polarimeter in the optical band has also been developed. Observations of Comet Halley, Comet Austin and Orion nebula have been made.