Bull. Astr. Soc. India (1999) **27**, 335-338

A two channel high speed photometer for lunar occultation studies in the near-IR

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Abstract. Lunar occultation in the near infrared has been demonstrated by the PRL group to be an effective method of determining the angular size (in milliarcsecond range) and accurate effective temperature of red giants, supergiants and carbon stars. Many of these object (T_{eff} ~ 3000 K) have cooler circumstellar material at temperatures less than ~ 1000 K. A lunar occultation observed simultaneously of such a star in the K(2.2 μm) and L(3.6 μm) filter bands can provide a complete high angular resolution information on both the star and the circumstellar region. For this purpose a two-channel fast photometer operating in the K and L bands has been developed recently at PRL. It incorporates a special dichroic beam-splitter for separating the K and L beams and several improvements over existing single channel system.

Key words : lunar occultation-infrared-two channel-circumstellar shells

1. Introduction

The potential of the infrared lunar occultation technique to reach high angular resolution in the milliarcsecond (mas) range even with modest aperture telescope in the 1 m class provided the motivation for launching a program of lunar occultation observations at the Physical Research Laboratory. The early efforts in the optical I band (0.87 μm) are summarized in Chandrasekhar et al. (1992). Subsequently a near infrared fast photometer was built for occultation observations mainly in the K band (2.2 μm) (Ashok et al., 1994). Over 50 occultations, all in the K band, have been successfully observed till June 1997. A number of significant results have emerged which are discussed elsewhere in this volume.

During the course of occultation observations in the K band it was realized that if some of the events could be simultaneously recorded at a longer wavelength like L band (3.6 μm) then circumstellar structures could be better studied. An L band occultation of the source would have a strong shell signature in the diffraction pattern. The K band observations are also important because one can deduce the angular diameter of the star accurately without shell effects interfering unduly. Another advantage of simultaneous observations at two wavelengths is that the effect of lunar slope which is reflected in the difference between predicted and observed velocities of the fringes is neutralized.

2. Instrument description

The two channel photometer essentially consists of a photometer box, specially designed cassegrain plate for accommodating two liquid nitrogen cooled dewars and an IR beamsplitter. The optical layout with observational setup is shown in Fig. 1 along with the electronic subsystems. The photometer box incorporates a flip mirror system, a side source for alignment and signal calibration purposes without the telescopic beam. The flip mirror is coupled through a lens to a CCD cum eye-piece attachment. While the CCD is to be used for remote operation the eye-piece attachment is for centering the star at the telescope. The detectors are two independent liquid nitrogen cooled InSb dewars.

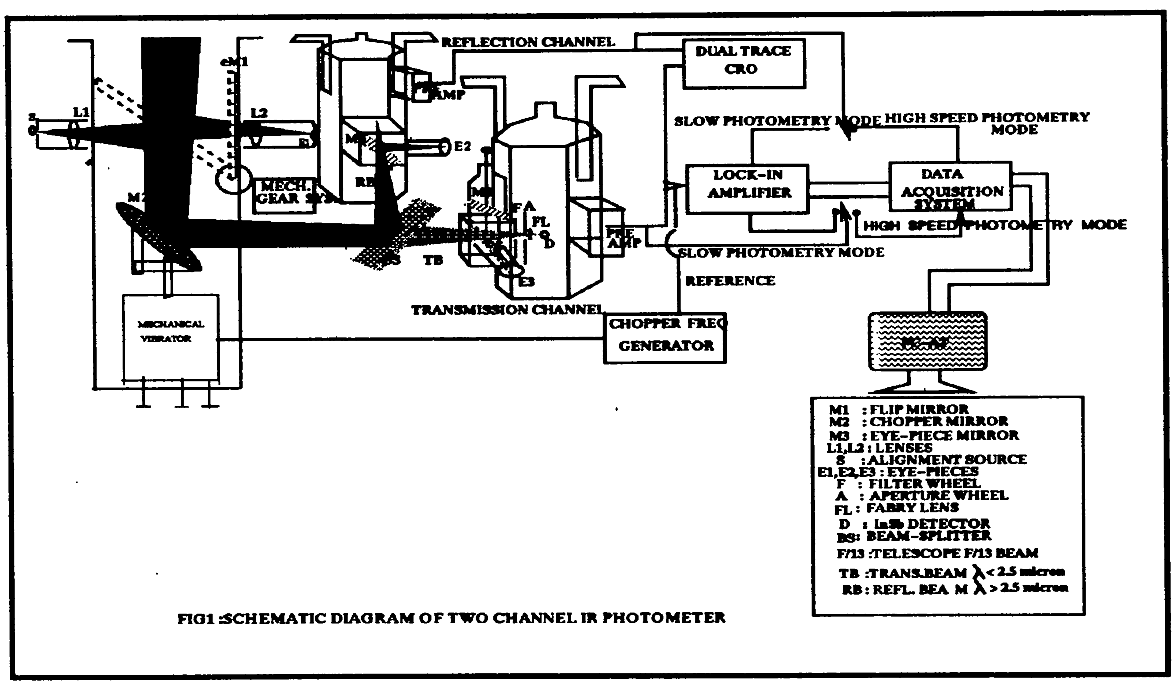

Figure 1. Schematic diagram of two channel IR photometer.

The f/13 beam from the telescope after right angled-reflection from chopper mirror is bifurcated by a special dichroic IR beam-splitter. The transmission channel covers J, H and K bands. The reflection channel is for L and M bands. The optical beam is focused on separate cooled apertures located in each of the dewars. The characteristics of the beam splitter is shown in Fig. 2. By the arrangement of mechanical gears and remote switching, the flip mirror can be introduced when necessary to divert the beam for viewing. The field

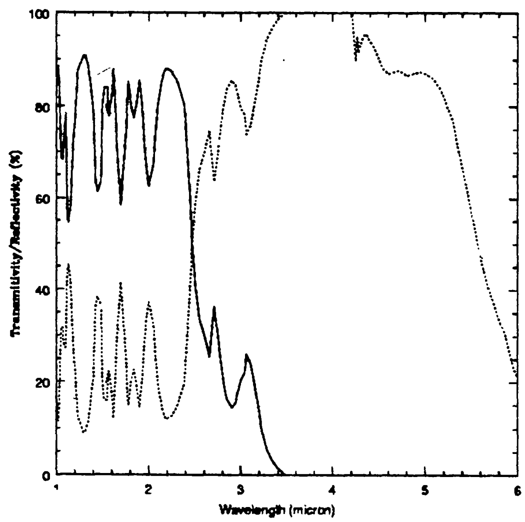

Figure 2. The characteristics curve of Beam-splitter. Solid line for transmission and dotted line for reflection.

eye-piece provides a large field of view on the sky (9.5 arcmin in diameter) by converting f/13 to f/4.17 beam. Presently the side source provides a f/15 beam for calibration and alignment purposes. For lunar occultations high sampling rate (~ 1 kHz) is required. In the absence of a vibrating secondary mirror, a tertiary mirror chopper arrangement is needed for sky subtraction when the system is operated for slow speed photometric observations.

In occultation mode the lock-in amplifier and chopper are bypassed and the output signal from the detectors are directly fed to data acquisition system (DAS). In the slow speed photometry mode the output signal from the detectors is fed to lock-in amplifier followed by the DAS. A Keithley unit (model no. KDC 500/1) is used for simultaneous two channel high speed 16 bit analog signal sampling. The DAS incorporates a powerful Graphics program which enables any portion of the sampling data to be displayed, once the event is over.

3. Status

The instrument weighs about 75 Kg and has been successfully integrated with the 1.2m Gurushikar telescope. An occultation of R Leo has been recorded at a wavelength of 3.2 μm with a bandwidth of 0.05 μm. Recent alignment tests have made it possible to obtain two channel photometry. The system awaits a bright star event in the coming months for recording two channel occultation light curves. Fig. 3 shows the actual instrument coupled to the backend of the 1.2m Gurushikar telescope.

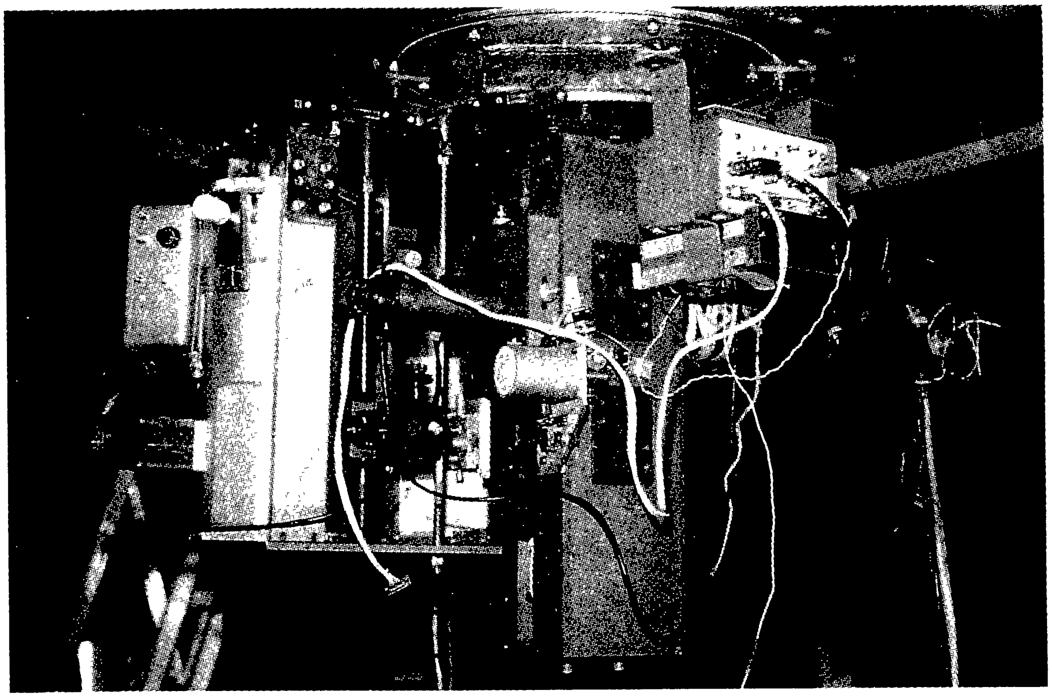

Figure 3. The two channel IR photometer coupled to the 1.2m Gurushikar telescope. The InSb detector dewars can be seen attached to the photometer box along with the auxilary electronics.

Acknowledgement

We are grateful to our workshop engineer, Mr. A. J. Shroff for designing the flip mirror motorised system. The project is supported by Dept. of Space, Govt. of India.

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