NEAR INFRARED HIGH ANGULAR RESOLUTION OBSERVATIONS OF STARS AND CIRCUMSTELLAR REGIONS BY THE TECHNIQUE OF LUNAR OCCULTATIONS

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Abstract. A program of High Angular Resolution observations of stars and their circumstellar regions using the technique of lunar occultations has been initiated at the 1.2 m telescope at Gurushikhar (24°39' N, 72°47' E), India. A liquid nitrogen cooled InSb detector based high speed Infrared photometer with millisecond data acquisition capabilities has been developed for the near Infrared region (1-5μm) and eight occultations have been successfully observed in the K band (2.2 μm). The sources are (IRC No. -10578, +10013, +20034, +30094, +20190, +20200, +20073 and +00198. The diffraction pattern is clearly seen in all the observations. A convolution analysis involving the system frequency response, filter bandwidth and one dimensional source structure has been carried out to fit the data. System capability has been determined to be ~ 6 milliarcseconds.

1. Introduction

The technique of lunar occultations presents a different approach to High Angular resolution in the sense that it is not the source itself that is observed but the diffraction pattern of the source produced by the sharp limb of the moon. One dimensional structure in the direction of occultation can be extracted from the observed fringe pattern after detailed analysis taking into account the frequency response of the detection system, the optical filter bandwidth and the telescope size. The lunar occultation technique has the advantage of (a) being a relatively simpler method suitable for small telescopes of the 1 m class; (b) having the potential to achieve one dimensional angular resolution at the level of a few milli arc seconds. In the near Infrared region (2μm) the technique has distinct advantages compared to the visible region; (a) The scattered lunar background radiation is greatly reduced at ~2μm permitting better S/N of the fringe pattern. The thermal emission from the lunar limb is also not large enough to affect the data at ~2μm; (b) The fringe pattern scales as $\sqrt{\lambda}$. The fringes in near IR are more spreadout (by a factor of 2) compared to visible region permitting easier sampling.

A program of observing lunar occultations in the near Infrared has been initiated at the 1.2 m telescope at Gurushikhar, Mt.Abu, India (72° 47'E, 24° 39'N, 1680 m). Several occultations have been successfully observed in the K band (2.2μm) with a InSb IR photometer. In this paper the experimental arrangement is briefly described and the observations made and the results derived are presented.

2. Experimental Setup

Fig.1 shows the schematic diagram of the IR photometric system. The f/13 optical beam from the telescope after a right angled reflection at the mirror M_1 is focused on a cooled aperture wheel (A) with selectable apertures located inside a liquid Nitrogen cooled dewar. The dewar also houses cold filters (F), fabry optics (L), an InSb detector (D) and associated electronics mounted on a cold plate with extensive baffling to avoid stray radiation. Dewar is electrically isolated from the telescope by the Teflon pieces used in the mounting plate. This effectively removes the electrical pick up noise at AC Mains frequency (50Hz) coming from the telescope side which can otherwise swamp the signal. Mirror M_3 permits light to be deflected into an eyepiece arrangement E_2 rigidly attached to the dewar for fine tuning the optical alignment. The tertiary mirror M_1 can be vibrated with a frequency from 10 to 15 Hz and with a displacement of ~ 2 mm

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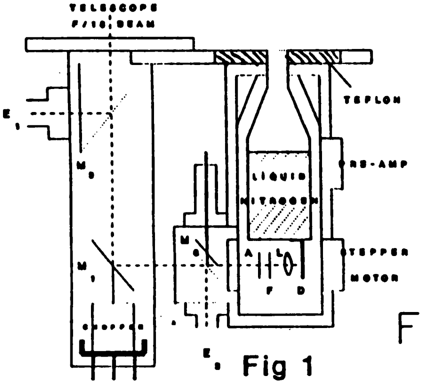

Fig 1

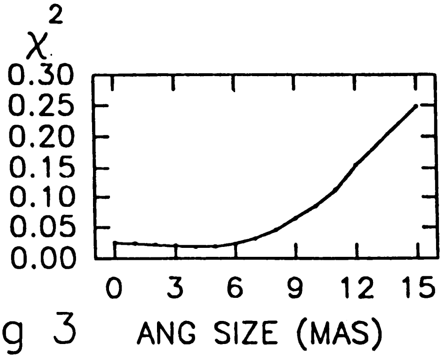

Fig 3

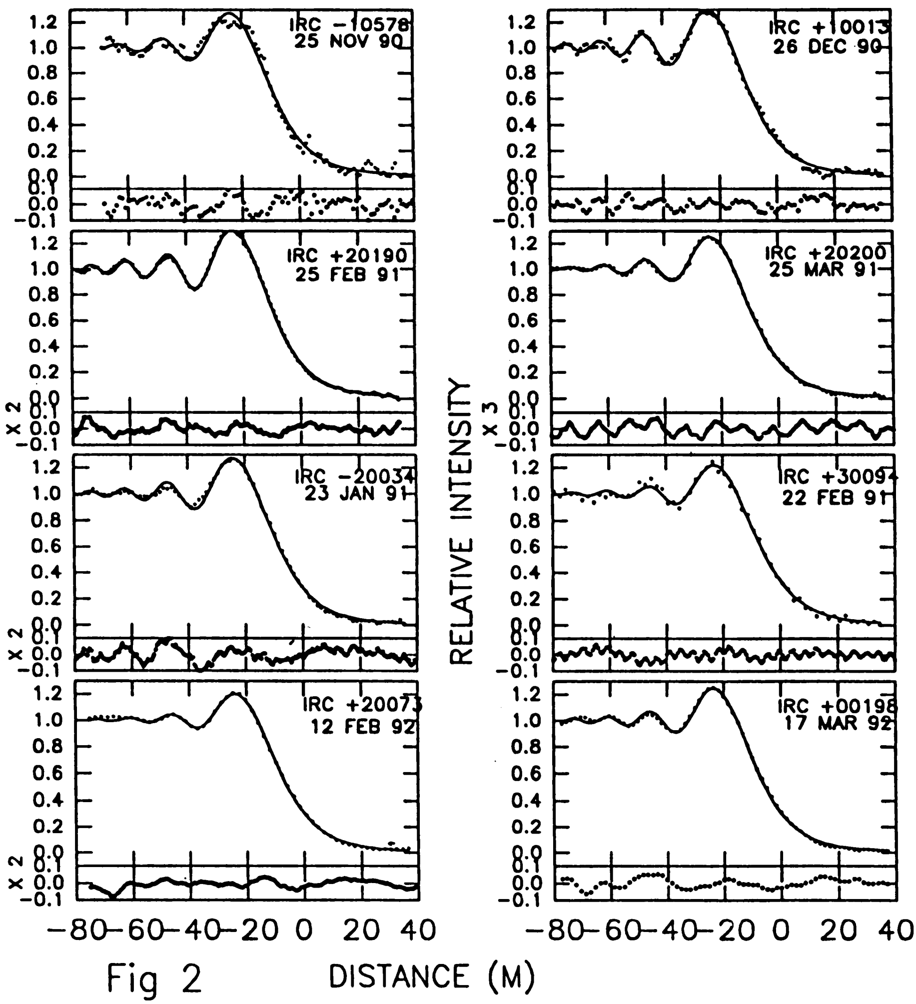

Fig 2

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corresponding to 26 arc sec on the sky at the 1.2 m telescope, whenever the photometer is used in the slow (photometry) mode. In the fast (occultation) mode there is no sky chopping and the detector/preamplifier output is directly digitized with a 16 bit A/D converter and recorded in a PC based data acquisition system. Data sampling is at the rate of 1 millisecond for 30 seconds centred on the predicted time of the occultation event.

TABLE 1: Observational details of the observed events.

IRC No.	Date	m_k	Sp type	Dist. (pc)/ Ang. size (mas)	Position angle	Vel. comp. (km/s)	
						Predicted	Fitted
−10578	25 Nov 90	2.04	K0/G8 III	26/5.7#	348.6°	0.3323	0.3450
+10013	26 Dec 90	1.94	M5	−/0.6#	356.3°	0.3582	0.3803
+20034	23 Jan 91	2.93	K1	−/1.8#	32.8°	0.5790	0.4580
+30094	22 Feb 91	2.51	−	−/−	326.5°	0.5738	0.6654
+20190	25 Feb 91	2.53	M0	310/1.9#	57.0°	0.3594	0.3157
+20200	25 Mar 91	1.42	K5	120/3.1*	74.9°	0.4925	0.5098
+20073	[2]12 Feb 92	0.95	M3	−/3.0+	280.8°	0.8558	0.7029
+00198	[2]17 Mar 92	2.85	M2 III	470/1.3#	273.2°	0.5606	0.5587

[2]1m telescope at Kavalur observatory
#Expected angular size (mas)
*Ridgway (1982)
+Richichi, et al. (1988)

3. Analysis & Results

The data analysis was performed using a least squares method of analysis first introduced in lunar occultation studies by Nather and McCants (1970). The point source function, smoothed over the spectral bandwidth of the filter is convolved with the source function which is taken to be a uniformly illuminated disk of a specified angular size. The fourier transform of the resulting function is then multiplied with the experimentally measured frequency response of the system and the inverse transform is taken to recover the profile which is then fitted to the data. A least-squares fit involving source brightness, lunar velocity component in the direction of occultation, central time of occultation and a fourth order polynomial to simulate background light level, low frequency scintillation noise and residual errors in the measured system frequency response has been carried out.
Results are shown in Fig. 2. The angular sizes to which the data is fitted are specified in Table 1. The fitted curve is shown by a continuous line. Data points smoothed over 3 sampling (3 milliseconds) are shown by circles. The residual curves (data − fitted value) are shown at the bottom of each plot suitably magnified. It is seen that the present system (Fig. 3) is sensitive to angular size in excess of ~ 6 milliarcseconds mainly limited by system time response. With in this limit the sources do not exhibit any structure. The results appear to be consistent with a model independent method of analysis evolved by Richichi (1989) in the few trial runs made by us so far. Further occultation observations with a faster detector system are planned.

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