NEAR INFRARED PHOTOMETRY OF SOME STARS

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INTRODUCTION

Infrared photometric stellar measurements in the J (1.2 μ) and H (1.65 μ) bands were made at the Cassegrain focus of the 104-cm, f / 13 Sampurnanand reflector at the Uttar Pradesh State Observatory during the period 29 November-2 December 1976.

These observations mark the beginning of infrared stellar photometry in India. A few measurements on the total amount of precipitable water vapour content in the atmosphere at the Observatory site (Lat. 29°21′.6 N, Long. 79°27′.4 E, altitude 1927 m) were taken during day time with a meter kindly loaned by Dr. J. Westphal of California Institute of Technology. These are given in Table 1.

In light of the above, the site shows a good potential for infrared observations at longer wavelengths. However, much more data would be needed for final conclusion.

TABLE 1

Total amount of Precipitable Water Vapour reduced to zenith at UPSO, Naini Tal

Date		Water Vapour (mm)
Nov.	09	3.7
	10	3.0
	11	4.3
	12	3.9
	13	3.0
	14	2.7
	15	2.5
	16	2.5
	18	3.0
	19	2.8
	24	*
	26	4.1
	28	3.2
	30	3.5
Dec.	01	3.3
	02	3.6
	03	3.4
	05	3.3

* Water vapour more than 7 mm.

INSTRUMENTATION

In the infrared photometer (Fig. 1), designed and built at the Physical Research Laboratory, a plane mirror, placed at a distance of 20 cm in front of the Cassegrain focus, deflects the incident beam through 90° on to the 1.2 μ or the 1.65 μ filter, with resolution $\Delta\lambda / \lambda = 0.1$. At the focus of the f / 13 beam a diaphragm wheel with 0.5, 1.0, 1.5 and 2 mm apertures is fixed (scale size, 1 mm = 16 arc sec.). Below the diaphragm, a Fabry lens focusses the primary of the telescope to a 0.77 mm diameter image on a 1×1 mm Pbs uncooled detector (D^* (2.5 μ, 750 Hz, 1 Hz) = 6.5×10^{10} w^{-1} cm $Hz^{\frac{1}{2}}$ and time constant $\tau = 200$ μS). On most of the measurements the 1.5 mm aperture was used. The mirror was vibrated vertically with a 2 mm amplitude at 16 Hz. The drive was a square wave with about 75% duty cycle. Thus, when the telescope was pointed to a star, the vibrating mirror would beam, star plus sky and sky alone alternately through the Fabry lens on to the detector, producing a dc signal for the sky background on which the star signal would produce a modulation.

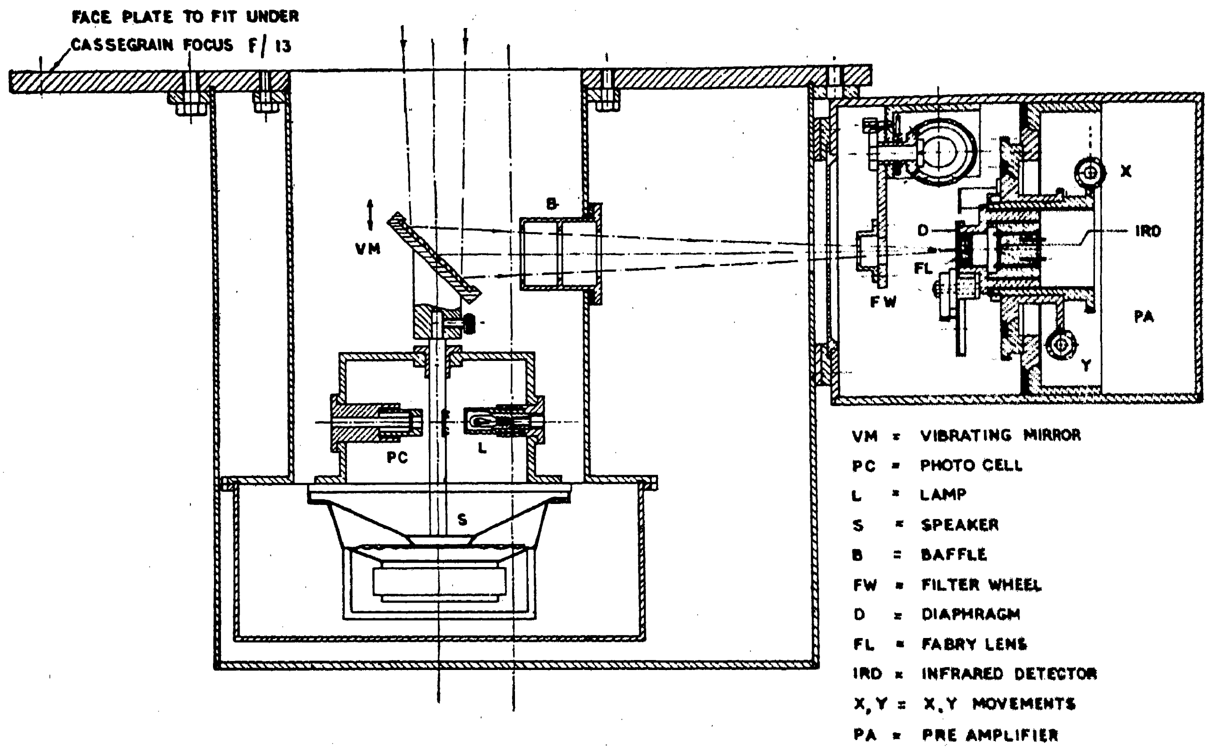

Fig. 1 : Filter photometer for near infrared astronomical observations.

The star signal was detected synchronously from a reference signal derived from the vibrating shaft of the mirror with a lamp and a photocell. The detector signal passed through a preamplifier, a tuned amplifier, a synchronous detector, a low pass filter and a d.c. amplifier and was recorded on a strip chart recorder. The signal to noise ratio, (S/N) on the records decreases with the increasing stellar magnitude, being approximately unity in the H band around $-0^{m}.36 \pm 0.074$. The error is less for brighter stars (S/N > 1) and more for fainter stars (S/N < 1).

The photometer was calibrated in the laboratory against a blackbody (secondary standard) at known temperatures, to enable reduction of observations to absolute values (Johnson 1966).

THE OBSERVATIONS

About 50 stars brighter than zero magnitude in the K band (2.2μ), one third of which are known to be long term visual variables, were selected from the 2μ Sky Survey Catalogue (Neugebauer and Leighton 1969—hereinafter referred to as IRC). Our observations have covered the spectral types given in Table 2.

These stars were within about 40° of the zenith when observed so that the extinction correction was not very important and was therefore not applied. Table 3 lists the results of the observations.

TABLE 2

Number of stars observed with their spectral types

Spectral Type	A	F	G	K	M	C
No. of observed stars	1	1	1	10	34	3

TABLE 3

Infrared Photometric Observations. The J & H magnitudes have been obtained in the present study. The spectral class and the V magnitudes have been taken from the literature

Star No. IRC	Star name	Spectral Class		Coordinates (1950) R.A.	Dec.	Magnitude V	J	H
60325	μ Cep	M2	II	$21^h41^m56^s$	58° 32′.6	3.99	—0.26	—1.34
00030	O Cet	M6	G	2 16 49	—3 12 .2	8.71	—1.75	—2.60
20087	∝ Tau	K5	III	4 33 04	16 24 .5	0.86	—2.17	—3.07
10100	∝ Ori	M2	II	5 52 28	7 24 .0	0.80	—3.38	—4.26
—20105	∝ CMa	A1	V	6 42 57	—16 38 .9	—1.45	—1.67	—1.54
10215	R Leo	M8	G	9 44 52	11 39 .8	5.00	—0.87	—2.08
00509	—	M3		21 43 58	—2 26 .6	7.16	—0.41	—1.52
50386	W Cyg	M4	G	21 34 10	45 9 .2	5.37	—0.34	—1.33
70168	T Cep	M7	G	21 8 52	68 17 .4	5.20	—0.41	—1.59
40019	—	M0	III	1 6 53	35 21 .0	2.03	—0.94	—1.76
00038	—	M2	III	2 59 40	3 53 .6	2.52	—0.76	—1.57
40054	ρ Per	M4	II	3 1 56	38 39 .3	3.39	—0.23	—1.29
50139	∝ Aur	G8	III	5 12 58	45 56 .4	0.09	—0.94	—1.25
20139	η Gem	M3	III	6 11 50	22 31 .7	3.30	—0.19	—1.07
20144	—	M0		6 19 58	22 32 .8	8.80	—0.87	—1.83
30209	RS Cnc	M6		9 7 38	31 10 .0	5.30	—0.54	—1.57
50049	—	Mb		1 55 35	45 11 .7	7.90	0.85	—0.06
20051	RZ Ari	M6	III	2 53 01	18 7 .3	5.94	0.15	—0.75
20112	CE Tau	M2	II	5 29 16	18 33 .8	4.35	0.04	—1.02
30194	β Gem	K0	III	7 42 14	28 8 .7	1.15	—0.71	—1.25
—10217	—	K4	III	9 25 10	—8 26 .6	1.99	—0.54	—1.34
—10588	—	M2	III	22 50 0	—7 50 .8	3.74	0.04	—0.52
30481	TW Peg	M8		22 01 41	28 6 .5	6.50	0.41	—0.48
00532	TX Psc	C6		23 43 49	3 12 .7	5.05	0.56	—0.36
60009	T Cas	M7	E	00 20 28	55 30 .2	6.70	0.85	—0.31
20038	—	K2	III	2 04 20	23 14 .1	2.00	0.15	—0.40
40034	—	K3	II	2 00 49	42 05 .4	2.10	0.41	—0.17
—10055	—	M0	III	3 55 40	—13 38 .5	2.96	—0.41	—1.23
70046	—	M1	G	3 44 52	65 22 .4	4.48	0.48	—0.59
30100	—	K3	II	4 53 45	33 05 .4	2.66	—0.09	—0.75
50141	R Aur	M7	G	5 13 16	53 31 .5	6.50	1.09	—0.06
50156	—	M3	II	5 56 14	45 56 .1	4.25	0.41	—0.59
40158	UU Aur	C5		6 33 07	38 28 .7	5.29	1.09	—0.12
10170	∝ CMi	F5	IV	7 36 42	05 21 .1	0.34	—0.63	—0.78
30210	—	M0	III	9 17 59	34 36 .4	3.14	—0.10	—0.84
—10242	U Hya	C7		10 35 03	—13 7 .3	4.92	1.24	—0.22
10235	VY Leo	M5	III	10 53 26	06 27 .0	5.81	0.48	—0.52
20219	—	K0	III	10 17 11	20 05 .6	2.61	—0.05	—0.69
40218	—	M0	III	10 19 21	41 45 .1	3.04	—0.05	—0.84
60208	—	K0	II	11 00 37	62 01 .2	1.79	0.27	—0.59
60363	—	M4	G	22 36 41	56 32 .1	5.23	0.85	+0.27
—10597	X Aqr	M5	G	23 14 17	—08 0 .0	5.04	0.96	+0.13
—10608	—	M3	IV	23 59 22	—06 17 .5	4.70	0.56	—0.12
00527	—	M3		23 08 40	04 44 .4	6.86	1.40	+0.53
10529	—	M4		23 06 56	08 24 .6	5.11	0.56	—0.27
20557	—	M3	III	23 55 11	24 51 .9	4.67	0.96	+0.06
60017	∝ Cas	K0	II	00 37 36	56 15 .5	2.24	0.65	+0.00
—10030	—	M5	G	01 57 57	—08 45 .9	5.51	0.96	+0.00
10072	—	M3		04 49 43	14 09 .6	4.74	0.34	—0.56
50180	Y Lyn	M3		07 24 34	46 06 .5	6.90	0.48	—0.48
10186	—	K4	III	08 13 50	09 20 .9	3.52	1.23	0.53

DISCUSSION

From the literature we were able to identify some stars for comparison in the wavelength bands in which we have taken observations. The comparison is given in Table 4. It will be seen that our values agree in general with those reported earlier (Neugebauer et al. 1971; Low 1968; Gillet et al. 1968), though there are some differences. From Johnson's earlier report (1964) we could get 10 common stars in J band only (He has no observations in H band). In most of the cases our values are consistantly higher compared to his. Recently Neugebauer (1977) has sent us a list of 36 stars whose magnitudes were measured by him in J and H bands (alongwith the other bands). Because this is his unpublished data we do not produce his results, however, the following table compares his values with ours.

TABLE 4

Comparison of fluxes from the stars

Star No. from IRC	Star Identity and Spectral Class	Flux values in Watt m^{-2} Hz^{-1} $\times 10^{-23}$			
		J (1.2 μ)		H (1.65 μ)	
60325	μ Cep	(1) 2.087	(2) 3.162	(1) 4.037	(2) 4.266
	M2 II	(3) 2.858			
00030	o Cet	(1) 8.201	(2) 9.332	(1) 12.89	(2) 11.48
	M6 G	(3) 10.76			
10100	∝ Ori	(1) 34.14		(1) 54.82	
	M2 II	(3) 28.05	(4) 24.30	(4) 23.26	
—20105	∝ CMa	(1) 7.60			
	A1 V	(3) 6.08			

(1) This report
(2) Neugebauer et al. (1971)
(3) Gillett et al. (1968)
(4) Low (1968).

	J	H
1. Total number of stars observed by us.	51	51
2. Number of common stars.	39	43
3. Number of stars for which agreement is within magnitudes :		
(a) 0.0 to 0.1	10	16
(b) 0.1 to 0.2	9	10
(c) 0.2 to 0.3	10	7
(d) > 0.3	10	10

This table again shows in general fair agreement. Our observations being of preliminary nature we shall not discuss the differences. Some differences could be genuine. However, our calibration of the photometer was against a blackbody (secondary standard) which could introduce systematic error. It may be noted that an accepted list of standard infrared star is not yet available (Neugebauer 1977).

In subsequent runs using cooled detector systems we propose to go to fainter stars and with different detectors and filters, take measurements at longer wavelengths.

ACKNOWLEDGEMENT

We are thankful to Dr. Neugebauer for sending some of his unpublished results for comparison.

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PRELIMINARY ANNOUNCEMENT

The Fourth Annual and Scientific Meeting of the Astronomical Society of India will be held at the Radio Astronomy centre, Ootacamund from Tuesday the 7th March 1978 to Thursday the 9th March 1978.