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JHK photometry of symbiotic stars

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Abstract. We present the results of multi-epoch JHK photometry of a sample of 30 known or suspected symbiotics and related objects. These are the first results of an ongoing programme of near-IR monitoring of symbiotic stars from the Mt. Abu IR Observatory of Physical Research Laboratory (PRL).

Key words: stars: binaries: symbiotic — infrared: stars — catalogs

1. Introduction

Infrared studies of symbiotic stars began with the pioneering work of Swings & Allen (1972). Later, Webster & Allen (1975) classified them into two types - S and D. The S-type stars are those with stellar continua of red giants in the infrared; the D-types are those having an infrared excess due to dust. The D-types have a Mira variable as the cool component, large mass-loss rates and more extensive nebulae than the S-types. The D-type systems show large amplitude variability in the infrared which is related to the Mira period; the S-type systems show minor variations or none at all (Feast et al. 1977). The nature of the cool component is an important constraint on binary models for symbiotic stars because its size, relative to its Roche lobe, determines whether mass loss occurs via tidal overflow or in a wind. This in turn is crucial in determining the nature of outbursts and of the surrounding nebulosity. Collective infrared properties of symbiotic stars have been used to understand the cool star in the symbiotic binary vis-a-vis single red giants and Miras (Kenyon & Gallagher 1983; Kenyon 1988; Whitelock & Munari 1992). Such studies are an important input for population studies and evolutionary scenarios (see for example, Munari & Renzini 1992). The large orbital period of symbiotics, more than a year for most of them, forces the observational programmes to be long-term. As an example, one can cite the exhaustive photometric project described in Munari et al. (1992). Our efforts in this direction are the topic of this paper.

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2. The observational programme

2.1. The sample

All Northern and accessible Southern symbiotics brighter than $K \sim 8$ and not fainter than 13 in V were chosen from the list of Allen (1984) and Kenyon (1986) as potential targets for observations. We reserved those in very crowded fields for observations at a later stage even though they fulfilled the above criteria. A few suspect or possible symbiotics (such as SS Lep) and those which were regular targets of AAVSO and VSNET observers (e.g.: NQ Gem, T Lyn) were also selected to be observed. Observations were scheduled at regular intervals in order to get good phase coverage, but bad weather often precluded a more complete set of data.

2.2. Observations

The observations were carried out using a LN_2-cooled InSb photometer at the Cassegrain focus of the 1.2 m telescope at PRL's Mt.Abu Infrared Observatory (72° 46′ 45.″9 E, 24° 39′ 10.″9 N; 1680 m) during 1995-97. A 2 mm aperture, corresponding to 26″ on the sky, was generally used, the chopper throw was $\sim 30''$ and the chopping frequency was kept at 15 Hz for dewar 2 and 8 Hz for dewar 1. Apertures of 1 and 3 mm were used on certain occasions and the chopper throw was correspondingly adjusted. The details of our experimental system are given in Ashok et al. (1994). Two different dewars – Dewar 1 (CVF) and Dewar 2 (New) – were used for obtaining the data. The filter responses of these two systems at the operating temperature of 77 K are given in Fig. 1. Our experience with both the dewars shows that they are essentially identical. Hence, all the measurements are referred to in the same

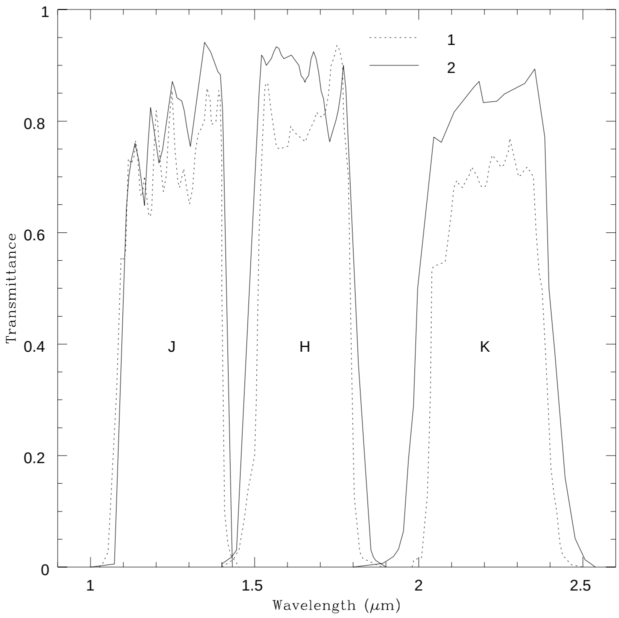

Fig. 1. Filter responses of the two dewars used for observations. They are traced from manufacturer's curves for the operating temperature of 77 K

system. The PRL filters, particularly K and H, are quite close to the new ESO filters; hence photometric standard stars were selected from Bouchet et al. (1991) and their magnitudes in our system were adopted to be the same as their ESO magnitudes. This procedure is necessitated by the fact that we are still in the process of properly calibrating our own photometric system. All the programme stars had their own nearby "prime" comparison star from the above list with respect to which the star magnitude was calculated. On days where other standards were observed, intercalibration among them was done. These observations are accurate to ±0.05 mag.

2.3. Results

The data obtained during the course of this survey is presented in Table 1. It lists data for a total of 30 known or suspected symbiotics and related objects. Most of them are S-type symbiotics. The programme objects appear in order of increasing RA. Remarks are noted in the last column, where the first digit denotes the dewar used and the second one refers to the aperture in mm.

3. Discussion

The present photometry, in conjunction with available JHK data, can be used to study the variability of symbiotics. For example, variations due to orbital motion are very clearly seen in the three bands in case of UV Aur

Table 1. Symbiotic stars and related objects: JHK observations. The two digits in the last column denote the dewar used (D) and the aperture in mm (A) respectively

Programme star	JD 2450000+	J	H	K	DA
EG And	439.15	3.83	2.46	2.70	12
	453.19	3.99	2.93	2.70	11
	473.10	3.79	2.92	2.66	12
AX Per	439.15	6.75	5.34	5.52	12
	453.19	6.81	5.75	5.44	11
	473.10	6.76	5.85	6.66	12
UV Aur	397.31	4.41	3.13	2.34	12
	439.15	—	—	2.38	12
	452.30	4.15	3.12	2.42	11
	474.41	3.97	2.90	2.22	12
	510.19	3.48	2.42	1.82	12
HD 35155	510.19	3.25	2.35	2.07	12
SS Lep	397.31	2.94	2.16	1.95	12
	439.15	—	—	1.57	12
	464.29	2.94	2.06	1.63	12
	474.41	3.13	2.18	1.81	12
	512.17	2.95	2.08	1.68	12
BX Mon	450.47	7.34	6.10	5.72	12
	483.31	6.97	5.93	5.62	12
	509.20	6.92	5.99	5.67	12
MWC 560	483.30	6.53	5.51	5.14	12
	509.20	6.53	5.50	5.11	12
ZZ CMi	463.43	4.14	3.15	2.87	12
	483.30	4.02	3.16	2.85	12
	509.20	4.24	3.20	2.92	12
NQ Gem	463.43	4.49	3.51	3.26	12
	483.30	4.51	3.51	3.22	12
	509.20	4.54	3.52	3.24	12
T Lyn	483.30	5.49	4.21	3.39	12
	509.20	5.49	4.18	3.40	12
CQ Dra	451.48	1.43	0.55	0.25	12
	557.31	1.46	0.57	0.29	12
TX CVn	85.50	7.27	6.37	6.28	22
	140.33	—	—	6.34	22
	202.14	7.52	6.72	6.28	22
	439.49	—	—	6.31	12
	451.48	—	7.49	6.29	12
	509.39	7.50	6.52	6.16	12
	556.35	—	—	6.19	12
RW Hya	28.48[a]	5.89	5.15	4.55	23
	29.15[a]	—	5.13	—	22
	85.50	—	—	4.74	22
	86.48	5.88	—	—	22
	119.37	—	—	4.75	23
	148.34	—	—	4.70	22
	203.18	—	—	4.79	22
	212.28	—	—	5.45	23
	463.43	5.84	4.92	4.76	12
	494.45	5.84	4.96	4.73	12
	556.35	6.20	4.89	4.63	12

Table 1. continued

Programme star	JD 2450000+	*J*	*H*	*K*	DA
BD −21°3873	203.18	—	—	7.01	22
	204.24	—	—	6.95	22
	581.27	9.72	8.70	7.23	12
T CrB	86.48	6.02	5.11	4.69	22
	116.42	—	—	4.76	23
	117.40	—	—	4.94	23
	118.40	6.02	—	—	23
	148.34	—	—	4.66	22
	212.28	—	—	5.20	23
	237.38	—	—	4.84	22
	557.31	5.90	4.99	4.71	12
	580.31	6.18	5.14	4.77	12
	581.27	6.06	5.11	4.76	12
AG Dra	557.31	—	—	6.44	12
AS 210	556.35	—	—	6.68	12
	581.27	9.56	7.86	6.39	12
	582.40	9.56	7.74	6.33	12
XX Oph	556.35	—	—	2.98	11
	581.27	4.49	3.34	2.82	12
RS Oph	556.35	—	—	7.05	11
	582.40	7.72	6.97	6.52	12
V2416 Sgr	583.44	6.70	5.24	4.63	12
AS 289	556.35	—	—	5.07	11
AS 296	556.35	—	—	4.31	11
	583.44	5.94	4.83	4.41	12
V443 Her	557.49	—	—	5.85	12
FR Sct	557.49	—	—	2.06	12
	582.40	3.95	2.69	2.20	12
CH Cyg	202.50	—	—	-0.40	22
CI Cyg	583.44	5.72	4.73	4.37	12
HM Sge	557.49	—	—	4.26	12
	583.44	7.36	5.84	4.42	12
V1016 Cyg	583.44	6.85	5.77	4.63	12
Z And	29.15[a]	—	—	5.39	22
	439.15	6.31	4.85	5.01	12
	453.19	6.47	5.34	5.03	11
	473.10	6.29	5.33	4.95	12
R Aqr	29.15[a]	—	—	-0.77	22
	397.31	—	—	-0.32	12
	453.19	-0.10	+0.01	-0.17	11

[a] JD 2449700 +.

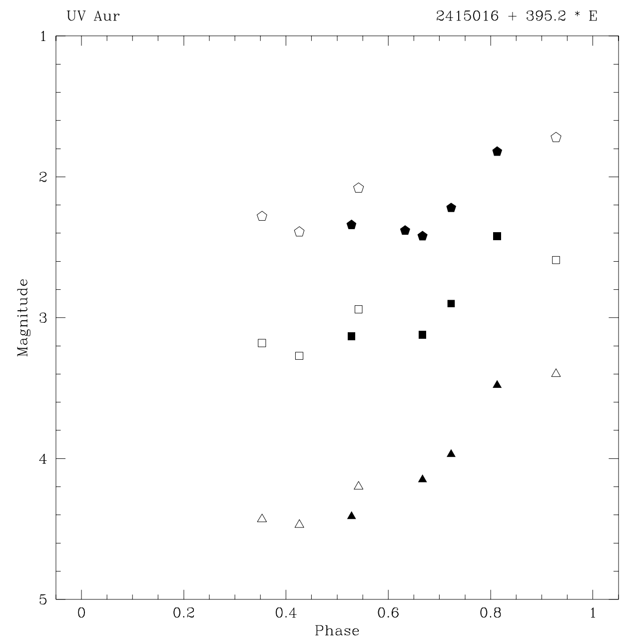

Fig. 2. Phase diagram for UV Aur. The orbital ephemeris is taken from Zakarov (1951). Filled symbols are our data and open symbols are data available in literature. *J* data are denoted by triangles, *H* by squares and *K* by pentagons

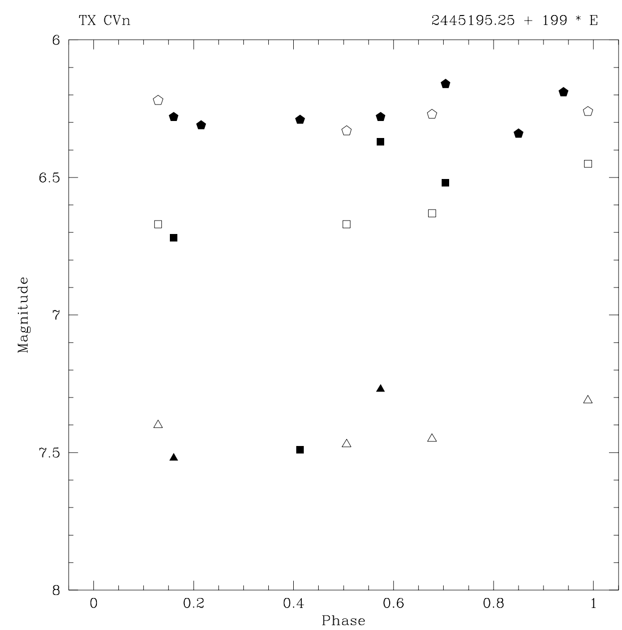

Fig. 3. Same as above but for TX CVn. The orbital ephemeris is taken from Kenyon & Garcia (1989)

(see Fig. 2). TX CVn also shows a phase-related modulation (see Fig. 3), especially in the *K* band. RW Hya shows a fair amount of scatter superposed on the small modulation (Fig. 4). The plot for AX Per (Fig. 5) hints at large intrinsic variability of the object. Data points in all the above figures are in different photometric systems; nevertheless, the observed scatter is more than can be accounted for by differences in the photometric systems.

Some of our data points have apparently anomalous values. We have checked our data carefully and definitely rule out instrument malfunctions or bad sky as the cause. It is interesting to note that such cases have been observed before. The symbiotic nova AS 338 was observed to be anomalously faint by Munari (1992). Munari et al. (1992) have found AS 327 to be unusually bright. The *K* magnitudes of AX Per as given by Swings & Allen (1972) and Szkody (1977) suggest strong variability. Kenyon & Gallagher (1983) found no evidence for the variability of AX Per, but our observations in the *K* band show an

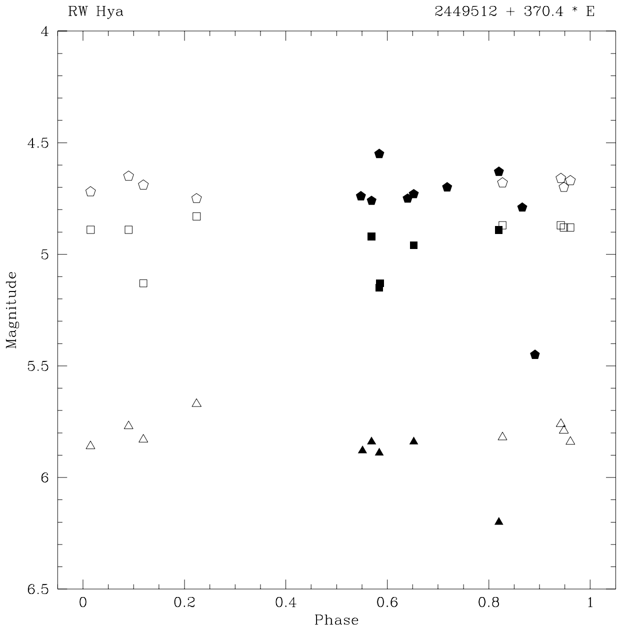

Fig. 4. Same as above but for RW Hya. The orbital ephemeris is taken from Schild et al. (1996)

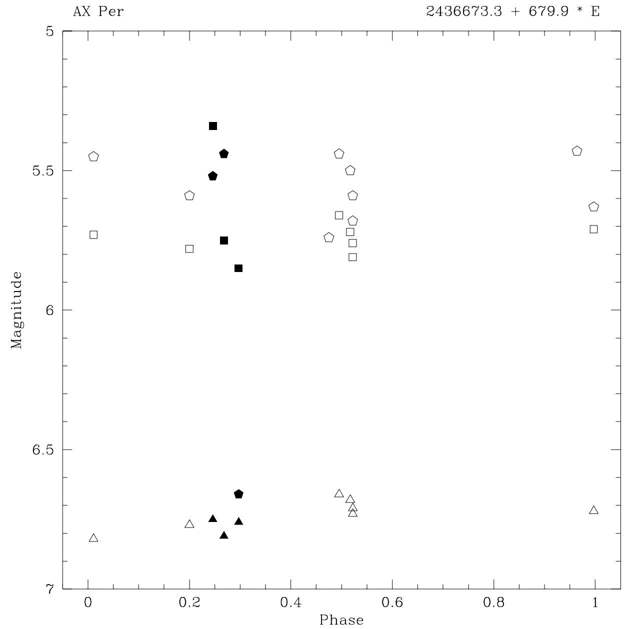

Fig. 5. Same as above but for AX Per. The orbital ephemeris is taken from Skopal (1991)

unusually faint data point. It seems that some symbiotics may occasionally show such flares or dips, the cause of which should be investigated in detail.

There still are significant gaps in the phase coverage of symbiotic stars in our sample and more complete light curves are therefore desirable. Pointed observations at specific phases are needed to confirm the reality of some of the unusual observations. This programme will be continued in the coming years also in order to study the various aspects outlined in Sect. 1. This data would be particularly useful in studying objects with little reported near-IR photometry – NQ Gem, ZZ CMi and T Lyn, for example.

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