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V, R & I LIGHT CURVES OF CONTACT BINARY SYSTEM AK Her

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AK Her is a W UMa type contact binary system, first detected by Pickering (1917). It is the brighter component of the visual binary ADS 10408, with the fainter component at a separation of $4''.7$. Previously obtained light curves show the primary minima fainter than the secondary minima and Max II fainter than Max I (Bookmyer 1972). The secondary minima observed by Bookmyer were also seen to be slightly shifted from phase 0.5.

Many studies have gone into the period variations of AK Her. The system was previously seen to be showing a sinusoidal $O - C$ curve and thus a periodic variation of the orbital period. Bookmyer and Kaitchuck (1979) suggested the presence of an unseen additional component in the system. Rovithis-Livaniou et al. (1999) and Varricatt, Ashok & Chandrasekhar (1995) have reported the departure of the recent values of $O - C$ from the sinusoidal nature. In this paper, we present new epochs of primary and secondary minima and an analysis of the light curves of AK Her obtained by us in the V, R & I photometric bands.

AK Her was observed from the Mt. Abu Observatory, Rajastan, India during 1994 with a $14'$ telescope and an HPC-1 Spectra Source CCD camera. Observations were done in the V, R & I bands using Johnson filters. BS 6337 was used as the comparison star. Fig. 1 shows the observed light curves in the three bands. We later noticed that BS 6337 is a variable (Percy & Fleming 1992). So part of the scatter in the light curve can be attributed to the comparison star. However, during the period of our observations, its variability would not have caused too big errors. Observations are taken over several orbital cycles covering many primary and secondary minima. The errors in the observed magnitudes are $0^{\rm m}.03$ in the V band and $0^{\rm m}.04$ the R & I bands. The observed light curves have light contribution from the visual companion. The system is slightly fainter around phase 0.75 than around phase 0.25 in all the three bands. The primary minima are deeper than the secondary minima and the secondary eclipse is total.

Times of minima are calculated by fitting a series of Legendre polynomials to the observations of the eclipse and applying a method similar to Kwee–van Woerden (Kwee & van Woerden 1956) to the fitted polynomial. Since, sometimes the observation of the light curve close to the minima were not very frequent, this was essential. Whenever there are observations of the same eclipse in different photometric bands, individually determined moments of minima are averaged to increase the accuracy of the determined epochs. 4 epochs of primary minima and 3 epochs of the secondary minima are obtained from our observations. The errors in the determined epochs are due to the inaccuracies in

the photometry and the insufficient sampling of the light curve around regions of minima. The epochs determined and the values of $O-C$ are given in Table 1. The $O-C$s are evaluated using the ephemeris given by Woodward (1942):

$$\text{Min I} = 2422977.254 + 0^{\text{d}}.42152207 \times E.$$

The values of $O-C$ evaluated from our data depart significantly from the previously considered sinusoidal $O-C$ curve and are consistent with the increasing trend seen by Rovithis-Livaniou et al. (1999) from their data taken during the period 1985–87, and Tunca et al. (1987). The epochs of primary minima obtained by Albayrak, Müyesseroglu & Özdemir (2000) also show this increasing trend of the O-C values. Recent work by Li, Zhang & Han (2001) shows that the period variation of AK Her contains one component of long term decrease and three other components of periodic variations.

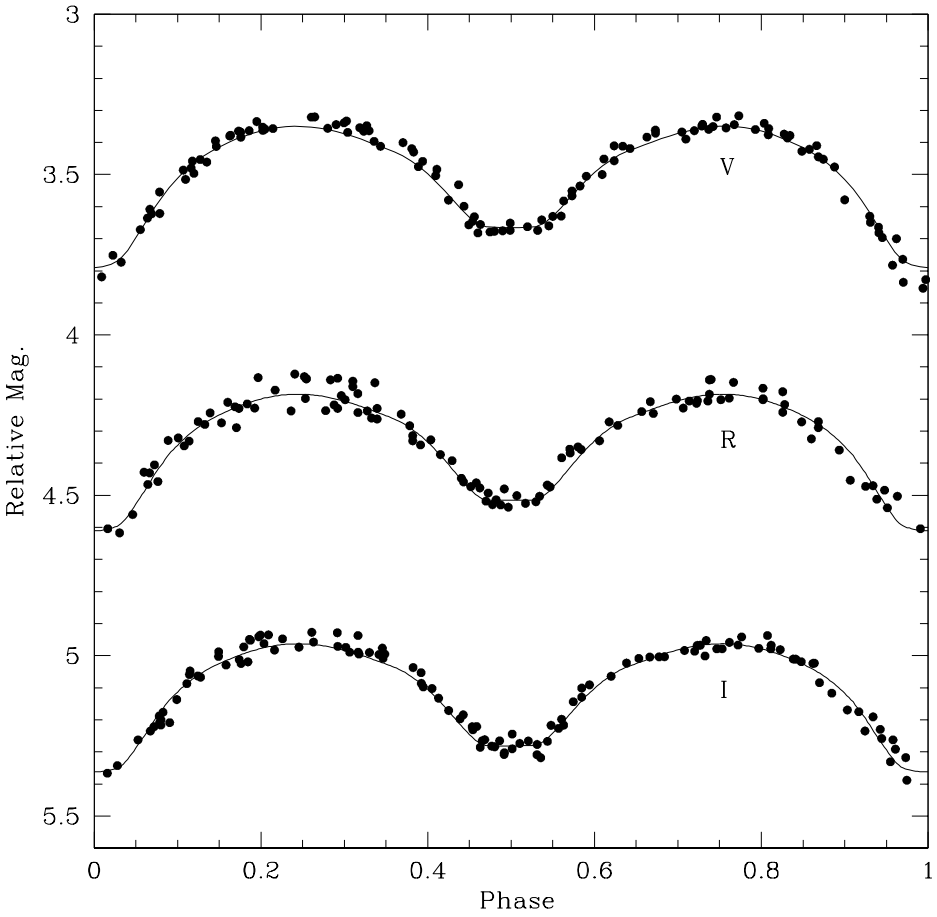

Figure 1. Filled circles show the observed points (AK Her – BS 6337). The model fit is shown by the continuous line

The observed light curves in the three bands, V, R & I are shown in Fig. 1. The observed points are normalized in phase bins of 0.014. V, R & I light curves are analyzed simultaneously using the Wilson–Devinney light curve interpretation program (Wilson & Devinney 1971, Wilson 1993). Due to the large noise in the light curves, we have not attempted a fit for all the parameters. The primary and the secondary temperatures (T_1 = 6400 K, T_2 = 6030 K), inclination ($i = 81^{\circ}.80$), mass ratio (q = 0.2331) and surface potential (Ω = 2.2980) were fixed to the values given by Lucy & Wilson (1979).

Table 1: The times of minimum light of AK Her, derived from the present observations

Hel. JD 2440000 +	Min. Type	Epoch	$O-C$ (days)
9486.3778	I	62889	0.0223
9490.3894	II	62898.5	0.0295
9491.4403	I	62901	0.0266
9492.2806	I	62903	0.0238
9494.3923	I	62908	0.0279
9495.4460	II	62910.5	0.0278
9496.2906	II	62912.5	0.0294

Table 2: Elements obtained from the analysis of V, R & I light curves of AK Her. A superscript f implies that parameter was fixed during the analysis

Parameter	Photometric Bands Observed		
	V	R	I
r_2/r_1		0.519	
x_1^f	0.600	0.470	0.400
x_2^f	0.620	0.490	0.390
$x_{1,\mathrm{bol}}^f$		480	
$x_{2,\mathrm{bol}}^f$		495	
$L_1/(L_1+L_2)$	0.842 ± 0.002	0.828 ± 0.002	0.824 ± 0.002
$L_2/(L_1+L_2)$	0.158 ± 0.002	0.172 ± 0.002	0.176 ± 0.002
l_3	0.032 ± 0.001	0.032 ± 0.001	0.036 ± 0.001

Gravity darkening coefficient was taken to be 0.32. A linear law was adopted for the limb darkening and the values were adopted from Al Naimiy (1978) and Van Hamme (1993) for the monochromatic and bolometric limb darkening respectively. The adopted values of limb darkening coefficients (x) are shown in Table 2. The reflection albedo was fixed at 0.5. The light curves were fitted with L_1, L_2 & l_3 as free parameters. Table 2 gives the parameters evaluated in each band. Subscripts 1 & 2 refer to the primary and the secondary components. L_1 & L_2 derived by us are similar to those obtained by Rovithis-Livaniou et al. (2001). The value of l_3 shown is the third light normalized by the systemic light at phase 0.25. The visual companion is expected to be the main contributor to the third light.

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