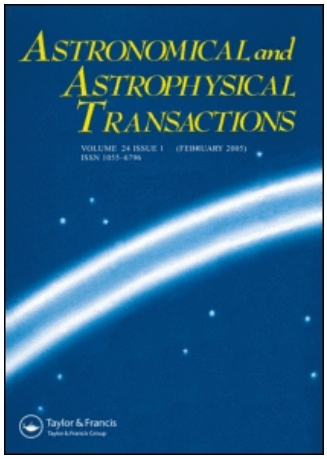

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

New photometric elements of AR Cas, an eclipsing binary system with apsidal motion

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Online Publication Date: 01 January 1992
To cite this Article: Mossakovskaya, L. V. (1992) 'New photometric elements of AR Cas, an eclipsing binary system with apsidal motion', Astronomical & Astrophysical Transactions, 3:2, 163 - 167
To link to this article: DOI: 10.1080/10556799208230553
URL: http://dx.doi.org/10.1080/10556799208230553

Astronomical and Astrophysical Transactions, 1992, Vol. 3, pp. 163–167
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NEW PHOTOMETRIC ELEMENTS OF AR Cas, AN ECLIPSING BINARY SYSTEM WITH APSIDAL MOTION

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(Received November 11, 1991; in final form December 24, 1991)

We have performed new photoelectric V observations of AR Cas, an eclipsing binary system with apsidal motion, mainly in Min II (Table 1). New, more precise photometric and absolute elements are given in Tables 2 and 3. We used observations by Catalano and Rodono (1971) for their determination. The third light L3 is equal to 0.45. The apsidal motion period obtained from the O–C curve, $U_{aps} = 922$ years, is approximately 2 times smaller than the theoretical one determined using Jeffery's (1984) constants of internal structure. The system deserves further observations.

KEY WORDS Eclipsing binary system, apsidal motion.

INTRODUCTION

The eclipsing binary system AR Cas (HD 221253, $V = 4\overset{m}{.}91$, $P = 6\overset{d}{.}0.66$,SP B3V + (A1)) was observed many times, but shallowness of its MinII ($\sim 0\overset{m}{.}035$) and the long period prevent the observers to obtain a sufficiently good light curve for determination of its photometric elements.

OBSERVATIONS

Photoelectric V observations of AR Cas were carried out in November 1986 at the Crimean Observatory of the Sternberg Astronomical Institute using a 60-cm reflector. The star 1 Cas (HD 218376, $4\overset{m}{.}93$, BO) was chosen as a comparison star. We used the 28″ aperture, so that only a faint B component ($\sim 9\overset{''}{.}3$) of the multiple system ADS 16795 at the distance $1\overset{''}{.}5$ was within the photometric field, but not other components. Results of the differential measurements of AR Cas with respect to the comparison star in the V band corrected for differential extinction are given in Table 1. From the observations, the moment of MinII was determined to be

$$\text{MinII} = \text{JD}_{\odot}2446746.2953 \pm 30.$$

Observing the variable outside the minima ($N = 7$) we have obtained the following average out-of-eclipse UBV values for this star: $V = \overset{m}{.}89$, $B - V = -0\overset{m}{.}10$, $U - B = -0\overset{m}{.}62$, which agree, within errors, with data of other authors.

Table 1 V-observations of AR Cas

$JD_{\odot}$ 244...	V $(v-c)$	$JD_{\odot}$ 244...	V $(v-c)$	$JD_{\odot}$ 244...	V $(v-c)$
6739.3499	0.058	6746.3171	0.063	6752.1550	0.044
.3511	0.030	.3218	0.070	.1578	0.042
6741.1883	0.022	.3251	0.066	.1604	0.038
6746.1861	0.072	.3287	0.067	.1652	0.062:
.1890	0.057	.3327	0.069	.1679	0.031:
.1932	0.058	.3359	0.065	.1706	0.041
.1960	0.077	.3400	0.068	.1725	0.043
.1987	0.067	.3432	0.070	.1758	0.040
.2026	0.072	.3468	0.064	.1785	0.034
.2055	0.063	.3508	0.068	.1857	0.050
.2084	0.058	.3545	0.070	.1912	0.044
.2111	0.076	.3580	0.068	.1937	0.053
.2141	0.063	.3628	0.059	.1964	0.051
.2179	0.077	.3665	0.064	.1989	0.051
.2207	0.074	.3711	0.070	.2013	0.046
.2235	0.085	.3753	0.075	.2038	0.056
.2264	0.069	.3791	0.049:	.2068	0.049
.2293	0.073	.3974	0.075	.2091	0.062
.2322	0.060	.4015	0.055	.2132	0.068
.2360	0.071	.4058	0.071	.2157	0.061
.2388	0.070	.4109	0.077	.2184	0.055
.2416	0.070	.4152	0.073	.2209	0.074:
.2451	0.070	.4200	0.064	.2234	0.065
.2477	0.076	.4246	0.064	.2259	0.058
.2525	0.068	.4293	0.064	.2287	0.047
.2554	0.072	.4368	0.064	.2313	0.053:
.2583	0.061	.4411	0.070	.2340	0.069
.2616	0.061	.4452	0.063	.2364	0.065
.2646	0.073	.4499	0.060	.2387	0.068
.2682	0.067	.4536	0.062	.2420	0.063
.2713	0.062	.4587	0.062	.2447	0.070
.2742	0.062	.4626	0.062	.2470	0.065
.2770	0.072	.4794	0.037	.2492	0.074
.2799	0.066	.4828	0.044	.2518	0.062
.2828	0.066	.4863	0.054	.2542	0.063
.2871	0.066	.4907	0.043	.2565	0.050:
.2903	0.067	.5008	0.039	.2633	0.065
.2935	0.058	.5047	0.037	6758.1734	0.028
.2966	0.071	6751.1569	0.037	.1765	0.039
.2995	0.067	.1606	0.032	.1790	0.018
.3035	0.064	6752.1416	0.044	.1815	0.025:
.3071	0.060	.1450	0.037	6759.1780	0.033
.3104	0.065	.1480	0.039	.1825	0.041
.3137	0.065	.1513	0.033		

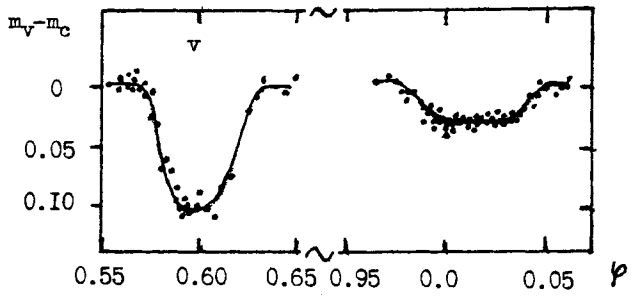

Figure 1 The summary light curve in the v band for AR Cas used for determination of the photometric elements of this system (the out-of-eclipse magnitude assumed to be zero). Solid line is the theoretical light curve based on the calculated elements in the v band.

PHOTOMETRIC AND ABSOLUTE ELEMENTS

The photometric elements have been determined using the iterative method of differential corrections (Khaliullina and Khaliullin, 1984) devised for analysis of the light curves of eclipsing stars at elliptic orbits. The analysis has been carried out involving our individual V measurements given in Table 1 and those published by Catalano and Rodono (1971) in the bands b and v. The summary light curve in the v band is given in Figure 1. The light curve in the b band is taken from Catalano and Rodono (1971).

Table 2 contains the photometric elements found and the elements obtained by

Table 2 The photometric elements of AR Cas

Stebbins (1921)	*Huffer and Collins (1962)*	*This paper* "b"	"v"
r_1 0.192	0.1523 ± 0.0051	0.1570	0.1633
r_2 0.066	0.05304 ± 0.00002	0.06231	0.06398
i^0 84.5	88.41 ± 1.27	89.95	88.8
e 0.25	0.24 ± 0.02	0.20	0.21
ω^0 37.25	34 ± 5	26.30	33.21
$L1$ 0.970	—	0.5148	0.5210
$L2$ 0.030	—	0.0248	0.0290
$u1$ —	≤ 0.40	0.43	0.34
$u2$ —	≤ 0.40	0.77	0.58
σ —	—	0.0050	0.0046
N 75	302	89	95

Table 3 The absolute elements of AR Cas

	$R_\odot$	$\mathfrak{M}_\odot$	*Sp*	T^0_{eff}	$B-V$	A_v	$d(ps)$	M_{bol}	M_v
prim. comp.	4.58	6.7	B3V	18600	−0.09	0.47	225	−3.64	−1.60
secon. comp.	1.81	1.9	B8V	11620	0.06			0.42	1.26

Stebbins (1921) and Huffer and Collins (1962) from their observations. We have used theoretical darkening coefficients $u1$ and $u2$ by Grygar *et al.* (1972) for our determinations.

It is clear that $L1 + L2 \neq 1$ for both summary curves. For the solution with the least standard deviation ($\sigma = 0.^m0046$ for the v band), $L3 = 0.45$. We have also determined the photometric elements using the observations in MinI by Gordon and Cron (1973). For these light curves the contribution of the third light is smaller: $L3 = 0.08$, but the confidence in this solution is smaller because the error is larger. Such value of $L3$ and the difference of $L3$ estimates from different light curves suggest that the third light is variable and its spectrum must be well detectable but we have not found such indications in the literature. We plan to continue photometric observations of AR Cas at least in the primary minimum to study the problem of the third light in this system.

We can obtain only the mass function for AR Cas because only the spectrum of the brighter component is seen in this object. Using $f(m) = 0.095$ (Gaida and Seggewiss, 1981), adopting for the main component B3V $\mathfrak{M}_1 = 6.7..$ (Svechnikov and Taidakova, 1984) and using photometric elements obtained here we have derived the absolute elements of AR Cas given in the Table 3. The semi-empirical method of Khaliullin (1985) gives very similar results. Our absolute elements agree with the previously published data; only the secondary component spectrum was determined by Koch *et al.* (1970) as $A1$ and by Gordon and Cron (1973) as $A5$–$A7$ from the six-colour photometry.

APSIDAL MOTION

From the difference of the periods of MinI and MinII in the O–C curve (Figure 2) we have established the apsidal motion period using the method of Rudkjobing (1959) as $U_{aps} = 922$ years, where the following elements have been adopted: $P = 6.^d0663309$, $P_p = 6.^d0663342$, $P_s = 6.^d0662859$, $e = 0.21$ and $\omega = 33.^o2$. Using

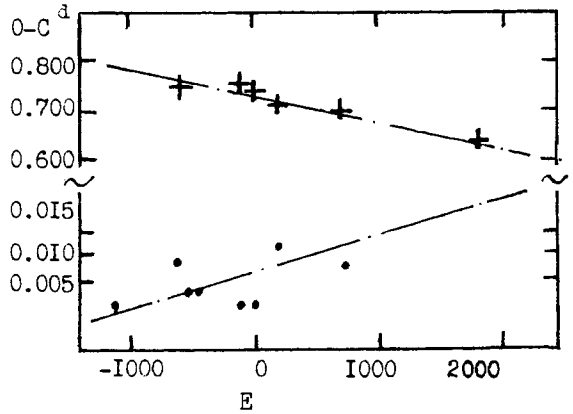

Figure 2 The O–C curve for the photoelectric moments of MinI (.) and MinII (+) for AR Cas (the original and published data used). O–C is calculated using the Huffer and Collins (1962) elements.

theoretical values for the constants of internal structure (Jeffery, 1984) and the photometric elements for the v light curve obtained here we have determined the theoretical apsidal period to be 2.3–2.6 times longer than the period obtained from the O–C curve. However, our apsidal period of 922 years agrees, within the errors, with $U_{aps} = 1000$ years found by Catalano and Rodono (1971) from displacement of MinII. So the problem of the apsidal motion period determination for AR Cas needs further photoelectric observations in MinI and MinII.

References

Catalano, S. and Rodono, M. (1971). *Astron. J.* **76,** 557.
Gaida, M. and Seggewiss, W. (1981). *Acta Astron.* **31,** 231.
Gordon, K. C. and Kron, G. E. (1973). *Astrophys. Space Sci.* **23,** 403.
Grygar, J., Cooper, M. L. and Jurkevich, I. (1972). *Bull. Astr. Inst. Czechosl.* **23,** 147.
Huffer, C. M. and Collins, G. M. (1962). *Astrophys. J. Suppl.* **7,** 351.
Jeffery, C. S. (1984). *Mon. Not. R. A. S.* **207,** 323.
Khaliullina, A. I. and Khaliullin, Kh. F. (1984). *Soviet Astr.* **61,** 393.
Khaliullin, Kh. F. (1985). *Astrophys. J.* **299,** 668.
Koch, R. H., Plavec, M. and Wood, F. B. (1970). *Pennsylvania Univ. Publ., Astron. Ser.,* **XI.**
Rudkjobing, M. (1959). *Annales d'Astroph.* **22,** 111.
Svechnikov, M. A. and Taidakova, T. A. (1984). *Soviet Astr.* **61,** 143.
Stebbins, J. (1921). *Astrophys. J.* **54,** 81.