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CCD PHOTOMETRY OF THE ECLIPSING BINARY AR BOOTIS

M. WOLF[1], J. BOROVIČKA[2], L. ŠAROUNOVÁ[2], J. ŠAFÁŘ[3], E. ŠAFÁŘOVÁ[3]

[1] Astronomical Institute, Charles University Prague, CZ-180 00 Praha 8, V Holešovičkách 2, Czech Republic
E-mail: wolf@mbox.cesnet.cz

[2] Astronomical Institute, Czech Academy of Sciences, CZ-251 65 Ondřejov, Czech Republic

[3] Nicholas Copernicus Observatory and Planetarium, Kraví hora 2, CZ-616 00 Brno, Czech Republic

The eclipsing binary AR Bootis (= SVS 1266 = GSC 1999.0011 = FL 1630, $\alpha = 13^{\rm h}48^{\rm m}10\overset{\rm s}{.}40$, $\delta = +24^\circ55'26\overset{''}{.}6$, J2000; $V_{max} = 13.5$ mag) is a frequently observed, rather faint variable star. It was discovered by Kurochkin (1959, 1960) in the vicinity of the globular cluster M3, but the period of $P = 0.416718$ days determined turned out to be incorrect. Houck and Pollock (1986) obtained two photographic light curves in the span of 3 days. They revised Kurochkin's data and derived the new period of 0.34470 days.

The system was also observed visually by the BBSAG and Brno observers: Locher and Diethelm obtained 9 times of minimum between 1975 and 1980, four times of minimum were observed by Borovička and Dědoch in 1987–90 (Mikulášek et al. 1992, Zejda 1995). Recently, other photometric times of minima have been given by Diethelm and Blättler. No spectroscopic observations have been published for this system.

We performed CCD photometry of AR Boo at two observatories. The system was observed in 1996–1998 at the Brno Observatory, Czech Republic, with a 40-cm Newtonian telescope and the CCD camera SBIG ST-7 without filter. Two color photoelectric photometry was done during the 12 nights from May to July 1997 at the Ondřejov Observatory, Czech Republic, with a 65-cm telescope and the CCD camera SBIG ST-6. Standard V Johnson and R Cousins filters were used. In most nights filters were changed between exposures, typically 120 seconds long. High signal-to-noise ratio enabled very good precision of the light curves, with standard error of measurements about 0.010 mag in R and 0.015 mag in V band. Altogether 183 measurements in R and 84 in V have been obtained.[1] The stars GSC 1999.0067 ($V = 12.9$ mag) and GSC 1999.0253 ($V = 12.9$ mag) – numbered 11 and 15 on the finding chart of Houck and Pollock (1986) – on the same frame as the variable served as a comparison and check stars, respectively.

Figure 1 shows the composite V, R light curves of AR Boo obtained in 1997. The light amplitude in primary minimum is $A_1 = 0.65 \pm 0.02$ mag and in secondary minimum $A_2 = 0.50 \pm 0.02$ mag in the R color. The amplitudes in V are very similar. The light curve seems to be typical of a β Lyrae type eclipsing binary. We also derived $V - R$ colour indices: 0.56, 0.59 and 0.37 mag for AR Boo in minimum, comparison and check stars, respectively.

[1] The table of observational data in ASCII format is available as the 4601-t2.txt file together with the electronic version of the Bulletin.

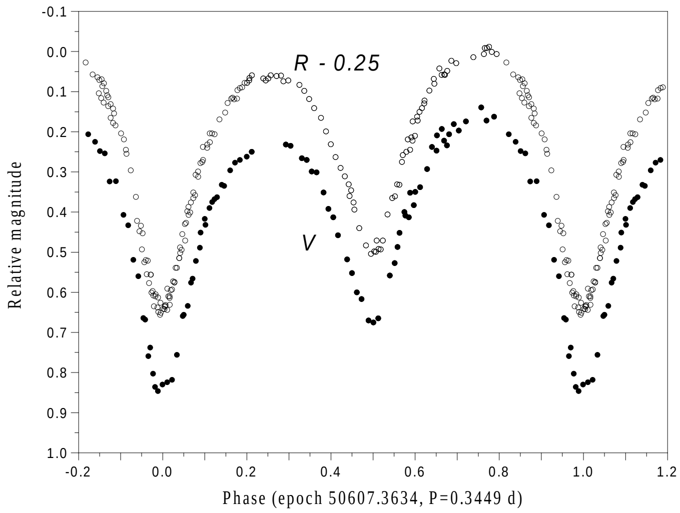

Figure 1. Composite differential V, R light curves of AR Boo computed using the new period of 0.3449 days. The R light curve is shifted by 0.25 mag

From the published photographic observations of Kurochkin (1960) we selected 12 times when the variable was fainter than 14.40 mag and defined them as plate minima. We also used the published observations of Houck and Pollock (1986) and determined three times of minimum light. Nevertheless, after a discussion with the first author, we revealed a systematic error in the published heliocentric Julian dates of -0.0661 days and corrected the times accordingly. From our measurements we derived 11 new times of minimum light and their errors using the method of Šarounová & Wolf (1996).

All available times of minimum (heliocentric Julian Date $-2\,400\,000$) are given in Table 1. The given errors apply to the last digit of the minimum time. For the ephemeris computation, the minima got a weight according to the observational method: plate minima (p) weight 1, visual (v) 5, photographic (f) 10, and CCD minima (C) 50.

A total of 44 moments of minimum covering the period 1950–1998 were incorporated in our analysis. They could not be fitted by a single period. The minima can be fitted either by a sudden period increase in about 1983 or by a continuous increase during the given period. The following light elements were calculated:

$$\begin{array}{lll} \text{Pri. Min.} = \text{HJD} & 24\,36661.541 & +\ 0.3448669 \times E \\ & \pm 4 & \pm 2 \end{array} \qquad (1)$$

for JD $<$ 2445400, and

$$\begin{array}{lll} \text{Pri. Min.} = \text{HJD} & 24\,50182.4799 & +\ 0.3448733 \times E \\ & \pm 3 & \pm 1 \end{array} \qquad (2)$$

for JD $>$ 2445400, or

$$\begin{array}{llll} \text{Pri. Min.} = \text{HJD} & 24\,36661.537 & +\ 0.3448646 \times E & +\ 1.17 \times 10^{-10} \times E^2 \\ & \pm 4 & \pm 2 & \pm 6 \end{array} \qquad (3)$$

for the whole period.

The parabolic elements do not explain satisfactorily the photographic minima of Houck and Pollock (1986) but they fit better the CCD minima from the recent years. The $O-C$ residuals for all times of minimum with respect to the linear ephemeris (1) are shown in

Table 1: The times of minimum of AR Boo

JD_{hel}	m.	E	$O-C_{1,2}$	$O-C_3$	observer	source
34133.336	p	−7331	+0.014	−0.004	Kurochkin	(1960)
34146.430	p	−7293	+0.003	−0.015	Kurochkin	(1960)
34834.449	p	−5298	+0.012	+0.002	Kurochkin	(1960)
35593.314	p	−3097.5	−0.002	−0.006	Kurochkin	(1960)
35600.384	p	−3077	−0.002	−0.005	Kurochkin	(1960)
36658.419	p	−9	−0.019	−0.014	Kurochkin	(1960)
36661.359	p	−0.5	−0.010	−0.005	Kurochkin	(1960)
36666.357	p	14	−0.012	−0.008	Kurochkin	(1960)
36666.565	p	14.5	+0.023	+0.028	Kurochkin	(1960)
36668.433	p	20	−0.006	−0.001	Kurochkin	(1960)
36687.415	p	75	+0.009	+0.013	Kurochkin	(1960)
36695.315	p	98	−0.023	−0.018	Kurochkin	(1960)
42575.486	v	17148.5	−0.005	+0.004	Locher	BBSAG
42576.519	v	17151.5	−0.006	+0.002	Locher	BBSAG
42775.697	v	17729	+0.011	+0.019	Locher	BBSAG
42780.516	v	17743	+0.002	+0.009	Locher	BBSAG
42872.594	v	18010	+0.001	+0.007	Locher	BBSAG
43624.395	v	20190	−0.008	−0.006	Locher	BBSAG
43656.479	v	20283	+0.003	+0.005	Locher	BBSAG
43662.524	v	20300.5	+0.013	+0.015	Locher	BBSAG
44343.442	v	22275	−0.009	−0.012	Diethelm	BBSAG
46140.7391	f	27486.5	+0.0019	−0.0074	Houck & Pollock	(1986)
46140.9091	f	27487	−0.0005	−0.0099	Houck & Pollock	(1986)
46143.8416	f	27495.5	+0.0006	−0.0088	Houck & Pollock	(1986)
47669.386	v	31919	−0.002	−0.004	Borovička	BRNO 30
47946.502	v	32722.5	+0.008	+0.007	Borovička	BRNO 31
47968.561	v	32786.5	−0.005	−0.005	Borovička	BRNO 31
47968.571	v	32786.5	+0.005	+0.005	Dědoch	BRNO 31
50182.4791 ±2	C	39206	−0.0008	+0.0002	Šafář	this paper
50192.4789 ±30	C	39235	−0.0023	−0.0013	Diethelm	BBSAG 112
50200.4128 ±2	C	39258	−0.0005	+0.0005	Šafářová	this paper
50200.5850 ±5	C	39258.5	−0.0007	+0.0003	Šafářová	this paper
50547.3555 ±2	C	40264	−0.0003	+0.0000	Šafář	this paper
50551.4936 ±18	C	40276	−0.0007	−0.0003	Diethelm	BBSAG 115
50607.3635 ±4	C	40438	−0.0003	+0.0000	Šarounová	this paper
50607.5346 ±3	C	40438.5	−0.0016	−0.0014	Šarounová	this paper
50611.5025 ±5	C	40450	+0.0002	+0.0005	Šarounová	this paper
50638.4028 ±2	C	40528	+0.0004	+0.0006	Šarounová	this paper
50888.4365 ±2	C	41253	+0.0010	+0.0005	Šafář	this paper
50899.4721 ±3	C	41285	+0.0006	+0.0001	Šafář	this paper
50923.4410 ±17	C	41354.5	+0.0008	+0.0003	Diethelm	BBSAG 117
50925.5099 ±14	C	41360.5	+0.0005	−0.0001	Diethelm	BBSAG 117
50926.3730 ±6	C	41363	+0.0014	+0.0008	Blättler	BBSAG 117
50927.4073 ±3	C	41366	+0.0011	+0.0005	Šafář	this paper

Figure 2. The non-linear fit, corresponding to the calculated elements (3) is plotted as a dashed curve. Further observations are needed to decide about the character of period changes in this interesting system.

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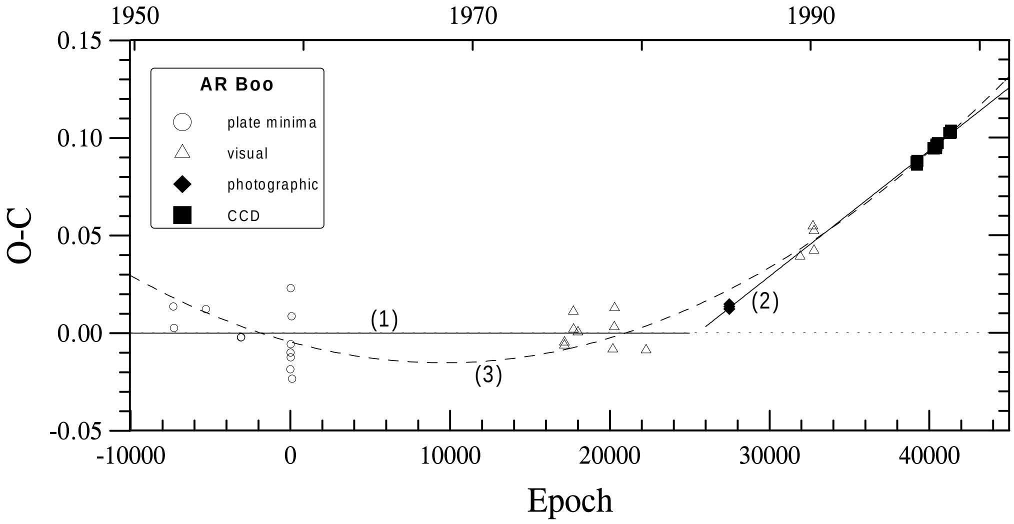

Figure 2. $O - C$ diagram for AR Boo

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