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CCD PHOTOMETRY OF THE ECLIPSING BINARY HV AQUARII

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The W UMa type eclipsing binary HV Aquarii (BD $-3°5183$, GSC 5198.0659, PPM 205095, $\alpha_{2000} = 21^{\rm h}21^{\rm m}25\overset{\rm s}{.}3$, $\delta_{2000} = -3°9'37''$, $V_{\rm max} = 10\overset{\rm m}{.}0$) is a relatively new variable with a short orbital period of about 9 hours. It was discovered by Hutton (1992) during a photometry of minor planets. The first photoelectric measurements were obtained independently in October 1992 by Schirmer & Geyer (1992) and Robb (1992). Schirmer & Geyer (1992) determined light elements from their high speed photometry using the secondary minima:

$$\text{Sec. Min.} = \text{HJD } 2448840.4548 + 0\overset{\rm d}{.}374460 \times E$$

and concluded that the spectral type is G5 according to the average $B - V = 0\overset{\rm m}{.}70$ They also noted, that both components show strong chromospheric activity. Robb (1992) based on his V, R CCD photometry, derived another ephemeris with longer orbital period:

$$\text{Pri. Min.} = \text{HJD } 2448835.7736 + 0\overset{\rm d}{.}374479 \times E.$$

He used the LIGHT modelling program for a determination of physical and geometrical parameters of the system. He concluded that HV Aqr is in a contact configuration with an extreme mass ratio $q = M_2/M_1 = 0.146$, inclination of 78.3 degrees and fillout factor 0.475 (solution in R filter). The temperature of both components was assumed to be 6500 K.

Our new CCD photometry of HV Aqr was carried out during two consecutive nights, 17 and 18 August 2000, at the Ondřejov Observatory, Czech Republic. A 65-cm reflecting telescope with a CCD-camera ST-8 was used. The measurements were done using the standard R filter with typically 10–15 s exposure time. The nearby stars GSC 5198.0636 ($V = 11\overset{\rm m}{.}4$) on the same frame as HV Aqr served as comparison star. Unfortunately, the star SAO 145329, used frequently as a comparison star by previous observers was over-exposed on our frames. The standard error of measurements, probably due to non-photometric conditions, varies between 0.01 and 0.03 mag. Two moments of primary and secondary minima and their errors were determined using the least squares fit to the data and by the bisecting cord method. These new times of minimum are presented in Table 1. The epochs were calculated using the new linear light elements.

Visual observations of HV Aqr were done by P. Molik in 1995 (5 August–26 October). He used a 0.2-m refractor at the Petrin Hill Observatory in Prague (Czech Republic). Visual estimates were done by the method of Nijland–Blazhko using a series of three

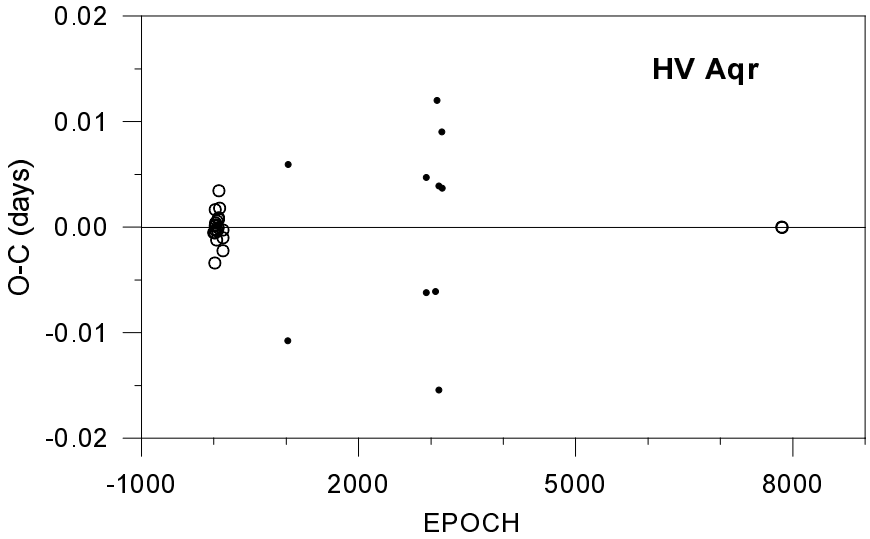

Figure 1. $O-C$ graph for the times of minimum of HV Aqr. The residuals corresponding to photoelectric and CCD data are denoted by circles, dots represents the visual timings of Martignoni and P.M.

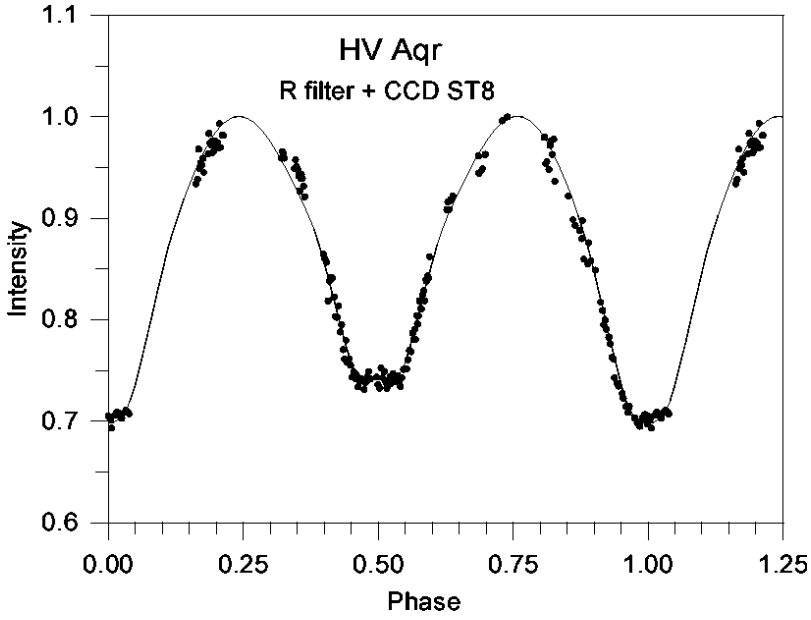

Figure 2. Composite R light curve of HV Aqr.

Table 1: Times of minimum of HV Aqr.

No.	JD Hel. − 2400000	Epoch	$O-C$ (days)	Method Filter	Source
1	48835.7737	0.0	−0.0005	pe R,V	Robb (1992)
2	48840.4544	12.5	−0.0005	pe V	Schirmer & Geyer (1992)
3	48841.5749	15.5	−0.0034	pe V	Schirmer & Geyer (1992)
4	48842.5161	18.0	0.0016	pe V	Schirmer & Geyer (1992)
5	48843.4507	20.5	0.0001	pe V	Schirmer & Geyer (1992)
6	48844.7616	24.0	0.0004	pe R,V	Robb (1992)
7	48844.9481	24.5	−0.0003	pe R,V	Robb (1992)
8	48845.8848	27.0	0.0002	pe R,V	Robb (1992)
9	48850.5641	39.5	−0.0012	pe V	Schirmer & Geyer (1992)
10	48852.8126	45.5	0.0006	pe R,V	Robb (1992)
11	48853.9351	48.5	−0.0003	pe R,V	Robb (1992)
12	48858.8033	61.5	−0.0001	pe R,V	Robb (1992)
13	48859.7404	64.0	0.0009	pe R,V	Robb (1992)
14	48859.9275	64.5	0.0008	pe R,V	Robb (1992)
15	48862.5514	71.5	0.0035	pe V	Schirmer & Geyer (1992)
16	48866.8560	83.0	0.0018	pe R,V	Robb (1992)
17	48882.3932	124.5	−0.0010	pe V	Schirmer & Geyer (1992)
18	48883.3281	127.0	−0.0022	pe V	Schirmer & Geyer (1992)
19	48883.5173	127.5	−0.0003	pe V	Schirmer & Geyer (1992)
20	49217.523	1019.5	−0.011	vis	Martignoni (1996)
21	49219.412	1024.5	0.006	vis	Martignoni (1996)
22	49934.625	2934.5	0.005	vis	this paper
23	49935.550	2937.0	−0.006	vis	this paper
24	49983.481	3065.0	−0.006	vis	this paper
25	49989.490	3081.0	0.012	vis	this paper
26	49999.386	3107.5	−0.015	vis	this paper
27	50000.341	3110.0	0.004	vis	this paper
28	50015.325	3150.0	0.009	vis	this paper
29	50017.379	3155.5	0.004	vis	this paper
30	51774.5178	7848.0	0.0000	CCD R	this paper
31	51775.45391	7850.5	0.0000	CCD R	this paper

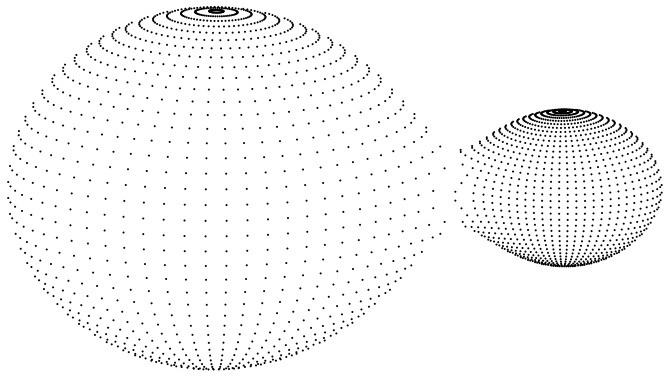

Figure 3. Geometrical representation of HV Aqr at phase 0.25.

comparison stars: GSC 5198.1260, GSC 5198.0999, and GSC 5198.0636. Total 192 estimates were obtained. The supposed mean error of a single estimate is ±0.05 mag. To avoid any prejudice about the behaviour of this low-amplitude star no prediction of times of minimum light was used.

The period of HV Aqr was studied by means of an $O-C$ diagram analysis. We took into consideration all photoelectric measurements of Schirmer & Geyer (1992) and Robb (1992) as well as results of our CCD measurements given in Table 1. A total of 21 photoelectric times of minimum light were used in our analysis, with 13 secondary eclipses among them. The new linear light elements

$$\begin{aligned} \text{Pri. Min.} = \text{HJD } 2448835.77422 &+ 0.37445764 \times E, \\ \pm 0.00033 \quad &\pm 0.00000014 \end{aligned}$$

were calculated by the least squares method. Our resulting period is about 2 seconds shorter than was obtained by Robb (1992). The $O-C$ residuals for all times of minimum are shown in Figure 1. The visual estimations of Martignoni (1996) and of the present paper are also plotted as dots.

Our R light curve was used for the preliminary determination of photometric elements using the Binary Maker 2.0 reduction software (Bradstreet 1993). The initial set of parameters was the same as in Robb (1992). We arrived at the following elements: $q = 0.18$, fillout factor 0.40 and inclination of 78.3 degrees in a good agreement with the previous solution. The temperatures were adopted to be $T_1 = 5500$ K and $T_2 = 5300$ K, which seems us to be more consistent with G5 spectral type. The computed light curve based on these new elements is compared with our measurements in Figure 2, the geometrical representation of HV Aqr at phase 0.25 is displayed in Figure 3.

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