COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5414

Konkoly Observatory
Budapest
15 May 2003

HU ISSN 0374 – 0676

HH UMa IS A CONTACT BINARY

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HH UMa (HIP54165, GSC 2521-1524, $\alpha_{2000} = 11^{\rm h}4^{\rm m}48^{\rm s}.1519$, $\delta_{2000} = +35^\circ36'26''.604$, $V_{max} = 10.58, V_{min} = 10.80$) is one of the variables discovered by the Hipparcos mission (ESA, 1997). In the Hipparcos catalogue it is classified as a periodic variable star of the F8 spectral type with the following ephemeris for the maxima:

$$\text{Max} = \text{HJD}2\,448\,500.155 + 0.1877470 \times E. \quad (1)$$

In the Simbad astronomical database (`http://simbad.u-strasbg.fr/`) the system is denoted simply as a variable star. Duerbeck (1997) lists HH UMa as a contact binary with the double period $P = 0.3755$ days since in such a case it obeys period-colour relation of contact binaries. Our observations show that the primary eclipse precedes JD_0 maximum by 0.5 of the pulsating period given by ephemeris (1). Then, the corrected Hipparcos ephemeris for the primary minima of contact binary HH UMa is:

$$\text{Min I} = \text{HJD}2\,448\,500.0611 + 0.375494 \times E. \quad (2)$$

HH UMa was observed during the tests of a new 50 cm Newton telescope in the G1 pavilion of the Stará Lesná Observatory of the Astronomical Institute of the Slovak Academy of Sciences. The telescope is equipped with the SBIG ST-10 MXE camera. The observations were obtained in Strömgren v filter on February 11, 2003 and in Johnson BV filters on February 12 and 22, 2003. The exposure times for the v and BV filters were 10 and 5 seconds, respectively. Due to the fast USB interface we obtained about 1000 observations in each filter. Hence, for clarity Fig. 1 (left) shows normal points from five observations (in average).

Second part of the CCD photometry was obtained at the Roztoky Observatory (RO) ($\lambda = 21^\circ28'54''$ E, $\varphi = 49^\circ33'57''$ N) on three nights on April 3, 4, 9, 2002. The 40 cm Cassegrain telescope equipped with the SBIG ST-8 CCD camera and standard Johnson VRI filters was used. For detailed description of the telescope and equipment see Pribulla (2003). The exposure times for the V and RI passband were 20 and 10 seconds,

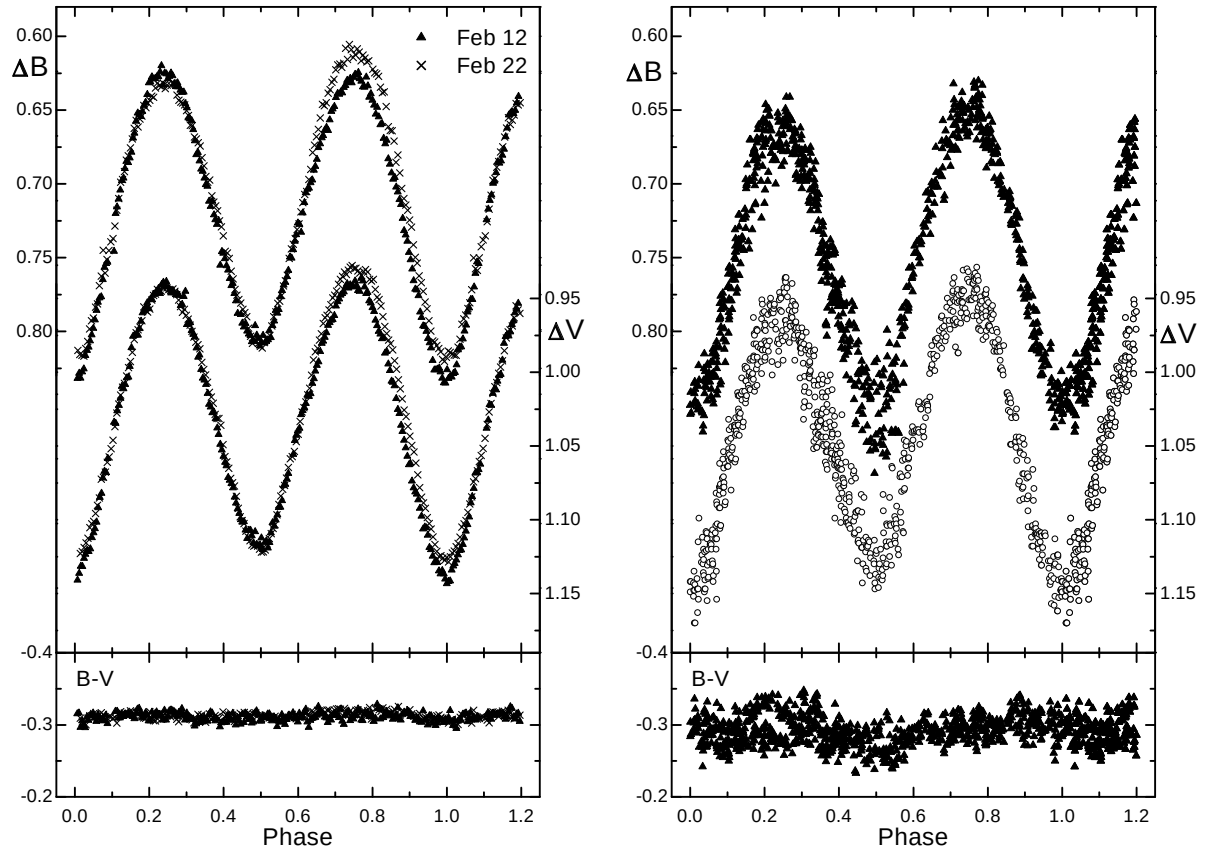

Figure 1: The BV CCD light curves and the $B-V$ colour index obtained on February 12 and 22, 2003 (left) and BV photoelectric light curves $B-V$ colour index from all nights (right). The data were phased according to the ephemeris (3)

respectively. The data are quite scattered due to bad sky conditions and short exposures. Therefore, they were used for determination of the minima times only.

The CCD frames in both cases were reduced in the usual way (bias and dark subtraction, flat-field correction) in MIDAS reduction package using procedures written by the first author. The brightness of the variable was determined by the aperture photometry with respect to BD+36°2151. Since the variable-comparison distance is less than $2'$ no extinction correction to the differential magnitudes has been applied. The resulting differential magnitudes were left in the instrumental system.

Some additional observations were obtained using 60 cm Cassegrain telescope in the G2 pavilion of the Stará Lesná Observatory of the Astronomical Institute of the Slovak Academy of Sciences. The 60 cm Cassegrain telescope equipped with a single-channel photoelectric photometer was used. HH UMa was observed in five nights: March 30, 2002, February 22, 23, 24 and March 2, 2003 in Johnson BV filters. Data reduction, the atmospheric extinction correction and transformation to the standard international UBV system were carried out in the usual way (see e.g., Pribulla et al., 2001). For all observations 10 second integration time was chosen. BD+36°2151 and BD+36°2150 were used as the comparison and check star, respectively. The check and standard star difference was found to be stable within 0.01 mag during all nights. The resulting BV light curves from all nights are shown in Fig. 1 (right).

The shape of the light curve as well as small variation (≈ 0.02 mag) of the $(B-V)$

colour index definitely prove that HH UMa is a contact binary. The system, however, seems to be active - the light curve shows small differences between individual nights. On most LCs the maximum I (phase 0.25) is fainter than the other maximum.

13 new minima times of HH UMa (Table 1) determined using the Kwee & van Woerden method (weight $w = 2$), together with corrected Hipparcos JD_0 (ephemeris 2, $w = 1$) provide new linear ephemeris:

$$\begin{array}{lll} \text{Min I} = \text{HJD } 2\,452\,368.3979 & + 0.3754937 & \times E. \\ & \pm 7 & \pm 3 \end{array} \tag{3}$$

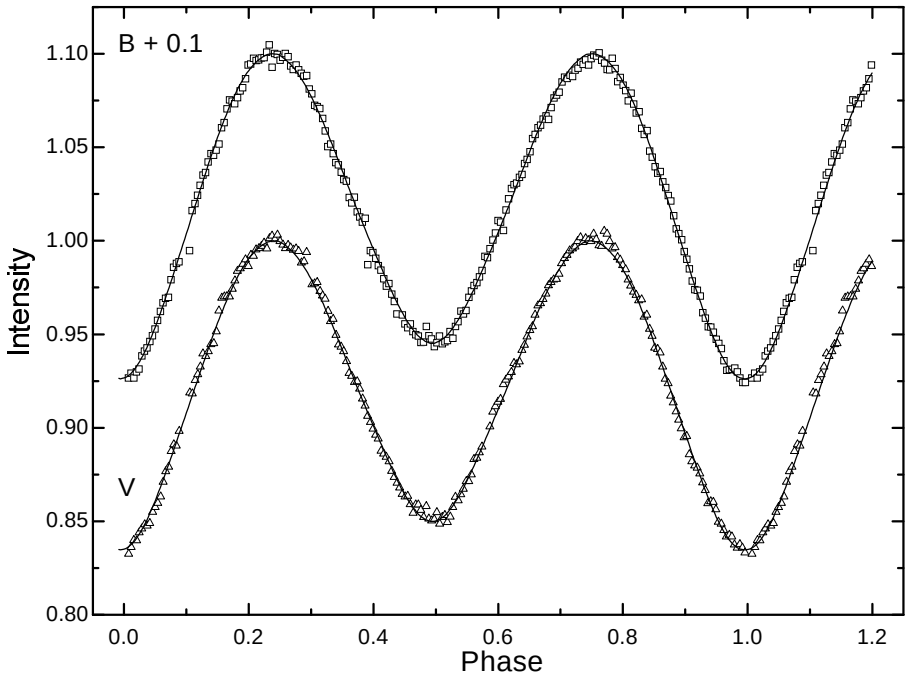

Figure 2. The best fits to the *BV* CCD light curves obtained on February 12, 2003

Table 1: Average *vBVRI* times of the primary (I) and secondary (II) minima. The standard errors of the minima are given in parentheses. The (O-C) residuals are given with respect to the ephemeris (3)

JD_{hel} 2 400 000+	Type	$(O-C)$ [days]	Obs.	Filters	JD_{hel} 2 400 000+	Type	$(O-C)$ [days]	Obs.	Filters
52368.3983(2)	I	−0.0001	RO	*VRI*	52683.4364(1)	I	−0.0011	G1	*BV*
52369.338(2):	II	0.0021	RO	*VRI*	52683.6236(3)	II	−0.0014	G1	*BV*
52369.5276(9)	I	0.0042	RO	*VRI*	52693.3863(9)	II	−0.0004	G2	*UBV*
52374.4074(9)	I	0.0011	RO	*VRI*	52693.3864(1)	II	−0.0003	G1	*BV*
52374.5915(5)	II	−0.0022	RO	*VRI*	52693.5772(2)	I	0.0030	G1	*BV*
52673.4881(2)	II	−0.0002	G2	*UBV*	52695.4540(6)	I	0.0009	G1	*BV*
52682.4958(3)	II	−0.0042	G1	*v*					

Since the spectroscopic mass ratio is unknown and the amplitude of the light variations is rather low, we tried to determine the photometric elements for several fixed mass ratios. We used symmetric *BV* LCs from 50 cm telescope obtained on February 12, 2003. Experiments with the new code *ROCHE* (see Pribulla, 2003) based on the Roche geometry, showed that the minimum sum of squares occurs around $q = 0.35 - 0.45$. The resulting photometric elements for fixed mass ratio $q = 0.40$ and temperature of the primary component $T_1 = 6200$ (corresponding to F8 sp. type) are $i = 52\overset{\circ}{.}6 \pm 0\overset{\circ}{.}9$, fill-out $F = 0.19 \pm 0.04$. The resulting fits are shown in Fig. 2. The detailed analysis of all individual light curves is under preparation.

Acknowledgements. This study was supported by ApVT grant 20-014402 and grant VVGS/014/2003/F (University of P.J. Šafárik, Košice).

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