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PERIOD CHANGES IN THE ECLIPSING BINARY DX Vel

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The eclipsing binary DX Vel (HD 297655, $P = 1.12$ days, $V = 10.2$, A5, detached Algol binary) was discovered and studied photographically by van Houten (1950). In 1978 van Houten obtained the precise photoelectric light curve of the object in the Walraven system. The observations were published by van Houten et al. (2009).

Our CCD photometry of DX Vel was obtained between May 2012 and January 2013, using the FRAM (Photometric Robotic Atmospheric Monitor): 0.3 m Schmidt-Cassegrain telescope located in Argentina near the town of Malargue and operated by Institute of Physics, Czech Academy of Sciences (for more details see Prouza et al., 2010). The telescope FRAM works in fully automatic mode using RTS2 software system (Kubánek et al., 2004) as a part of the atmospheric monitoring program of the Pierre Auger Observatory (for the description of the Pierre Auger Observatory see e.g. Abraham et al., 2010). The telescope is equipped with the CCD camera G2-1600 of Moravian Instruments and Bessel set of filters. The observations were acquired in the standard $BVRcIc$ system.

The light curve analysis of our data with the PHOEBE software (Prsa & Zwitter 2005), assuming the sphere-sphere model with reflection effect subtracted, provides the parameters given in Table 1. The corresponding fit of the R light curve is shown in Fig. 1. The solution allows as much as 12 percent of third light in the system. We obtained the same results from van Houten's and ASAS light curves of DX Vel. As seen in Fig. 1, Van Houten's observations show small but significant anomalies in colour changes in the primary minimum. The source of the extra U-light in the bottom of the primary minimum could be an F star object, the third body in the system.

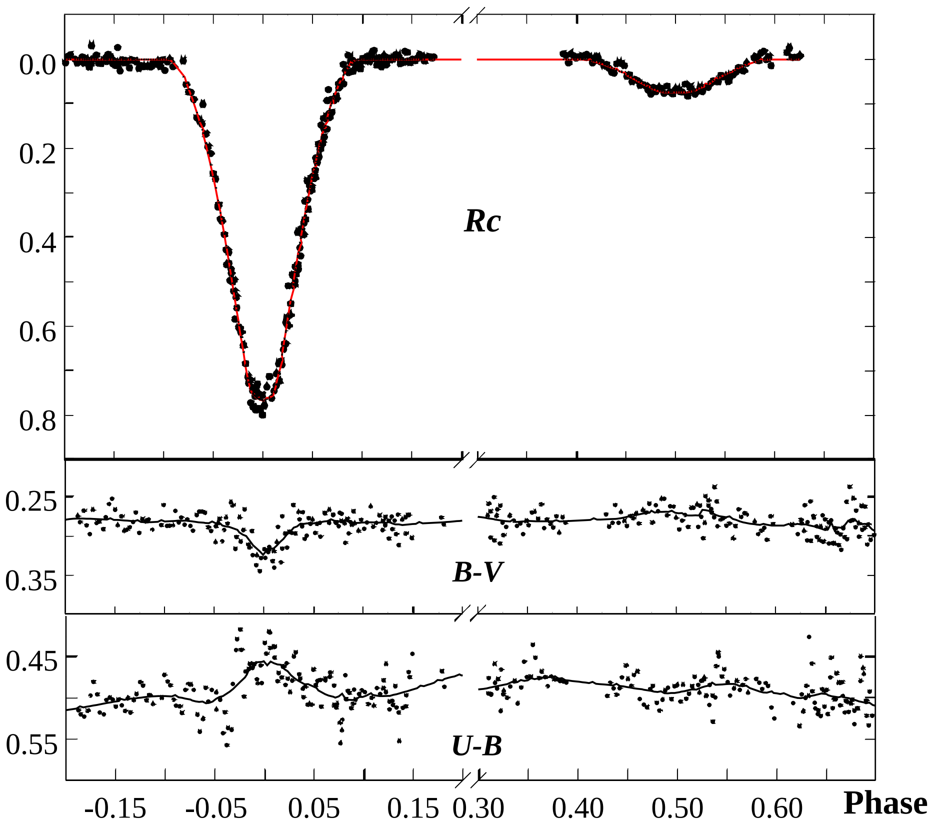

Figure 1. Part of our *Rc* light curve of DX Vel around both minima, taken by FRAM. Points denote the individual observations, solid red line stands for the theoretical fit, according to the parameters from Table 1 with L3=0.06. Van Houten's data transformed into $U - B$ and $B - V$ colours and phased with the same formula as *Rc* points are shown in two bottom panels.

In May 2012, Tiago Ribeiro obtained a spectrum of DX Vel during its primary minimum, with the 4-m SOAR telescope, using the GOODMAN spectrograph with the 1200 l/mm grating and the 0.46" slit allowing the spectral resolution of R=5900. The spectral classification was done by Daniel Sebastian, who classified the primary component of DX Vel as an A5 IV-III object. The classification was done by an automatic comparison of the spectrum with a catalog of template-spectra provided by Valdes et al. (2004). The used method is described in detail in Sebastian et al. (2012). The comparison of the part of our spectrum with the A5 III template is shown in Fig. 2. The size of the binary system with the orbital period 1.12 days is too small to contain an A5 subgiant or giant. The easiest explanation is to assume a third body in the DX Vel system, which affects the spectral classification.

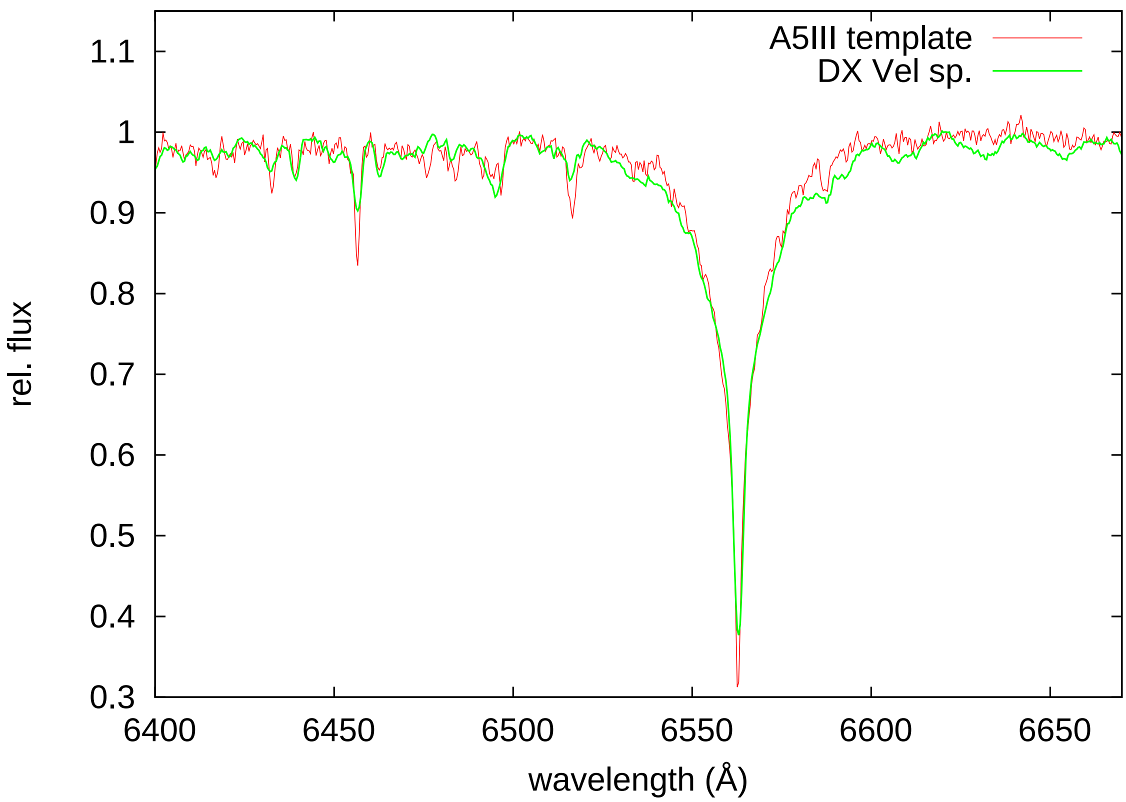

Figure 2. Comparison of the spectrum of DX Vel (green line) with the A5 III template (red line).

Table 1. Parameters of DX Vel

r_1	0.333 ± 0.002
T_1	$7400 \pm 300K$
r_2	0.236 ± 0.003
T_2	4400 ± 400
i	$85.4 - 89.9$ *

* depends on the value of the third light L3, varies from 0 to 0.12 in V and a little bit less in red and infrared.

All available primary minima times were used to construct the eclipse time variation (ETV) diagram. To derive the precise times of minima from photoelectric and CCD observations, we fitted the synthetic light curve through the individual observations by means of the least squares method. For simultaneous observations in several filters the timings of minima were weighted and mean values were calculated. To study the long-term period changes, we used 8 photographic minima times of DX Vel, published by van Houten (1950) and Hoffmeister (1951) to calculate one normal epoch of the primary minimum with a suitable precision. The ASAS data were divided into 6 intervals and normal minima for each interval were obtained. The times of minima are listed in Table 2. The $O-C$ residuals in the ETV diagram (Fig. 3) were calculated using the linear ephemeris: HJD Min I = 2443583.4618 + $1\overset{d}{.}11730385\times$E, obtained by the least squares method.

Table 2. Times of minima for DX Vel

HJD − 2400000	Cycle	Residual (days)	Remarks
29037.280(8)	−13019	−0.0030	photographic
43583.4660(2)	0	+0.0042	van Houten
51985.5894(7)	7520	+0.0027	ASAS
52578.8771(7)	8051	+0.0020	ASAS
53165.4619(6)	8576	+0.0023	ASAS
53870.4778(8)	9207	−0.0006	ASAS
54482.7602(10)	9755	−0.0007	ASAS
54967.6704(12)	10189	−0.0003	ASAS
56053.6880(5)	11161	−0.0021	our observations
56080.5031(6)	11185	−0.0023	our observations
56292.7906(4)	11375	−0.0025	our observations

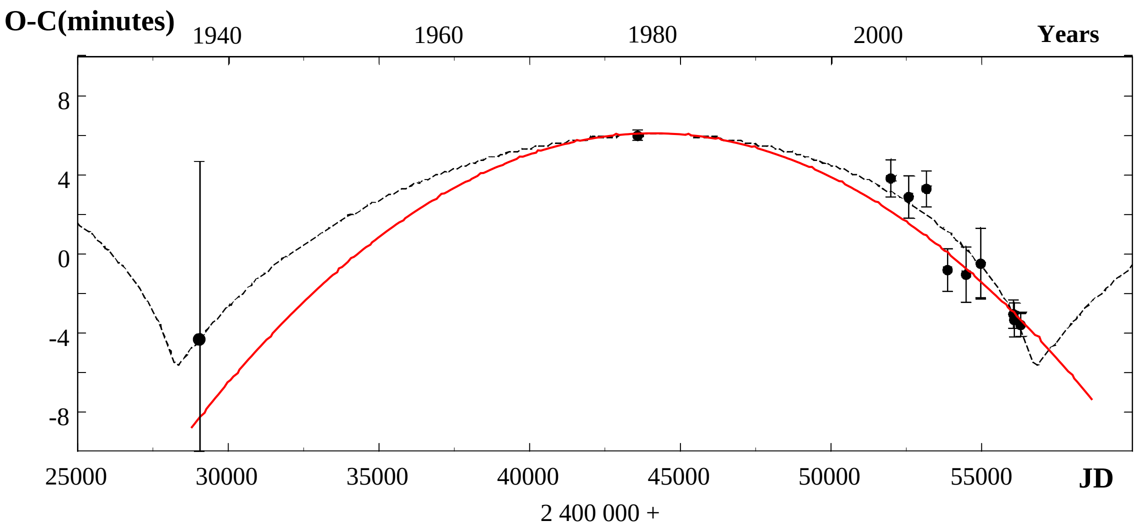

Figure 3. The ETV diagram for DX Vel. Solid red line - parabolic approximation, dashed line - the third body solution.

The minima times in ETV diagram can be fitted either by a parabola (continuous period change), represented by the following ephemeris:

$$\text{HJD Min I} = 2443583.4660(8) + 1\overset{d}{.}11730390(2) \times E - 5.51(4) \cdot 10^{-11} \times E^2$$

or by the third body orbit. Parameters of the formal third-body fit found by the least squares method are as follows:

$$P_3 \text{ (period)} = 28500 \pm 500 \text{ days, i.e. } 78.0 \text{ years}$$
$$T_0 \text{ (time of periastron)} = \text{J.D. } 2428200 \pm 500$$
$$A \text{ (semiamplitude)} = 0.00405 \pm 0.00020 \text{ day}$$
$$e = 0.9 \pm 0.1$$
$$\omega = 245^\circ \pm 15^\circ.$$

We would like to note that the similar situation in colour changes in minima had resulted in discovery of the third body in V577 Oph system (Volkov, 1991; Volkov & Volkova, 2010) and EQ Boo (Volkov et al., 2011, 2012).

We can conclude that the revealed orbital period change in DX Vel can be either real, caused by the mass transfer/mass loss effects or apparent, caused by the existence of the third body in the system.

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