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THE NEW ECCENTRIC ECLIPSING BINARY GSC 3152 1202

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The recently discovered binary system (GSC 3152 1202, $\alpha_{2000} = 20^{\rm h}27^{\rm m}17\overset{\rm s}{.}3$, $\delta_{2000} = +37^\circ 56' 27''$, $P = 2.094$) belongs to the list of "50 new eccentric eclipsing binaries found in the ASAS, Hipparcos and NSVS databases" published by Otero et al. (2006). The star is a rather faint eclipsing binary. The only photometric measurement available is the original ROTSE1 magnitude ($12\overset{\rm m}{.}69$).

We performed measurements in the V band at the Crimea Station of the Sternberg Astronomical Institute using the Zeiss-600 + an Ap47 CCD array in June 2009 and at the Tien Shan Astronomical Observatory using a Ritchey-Chretien-350 + an ST-402 CCD array in August 2009. The nearest neighbors GSC 3152 1174 ("c1") and GSC 3152 0488 ("c2") were used as comparison stars initially. We found the rms deviation of $\Delta m(var-c2)$ outside minima to reach $0\overset{\rm m}{.}008$. The rms-scatter $\Delta m(var-c1)$ reached $0\overset{\rm m}{.}011$. However, on June 22 the $\Delta m(var-c2)$ values had a trend of about $0\overset{\rm m}{.}1$ in 2.5 hours in contrast to the $\Delta m(var-c1)$ values. This behavior must be due to the variability of the star "c2". In any case in this study we used only "c1" (GSC 3152 1174) as the comparison star. The joint light curve is shown in Fig. 1. The data of individual measurements are accessible at the IBVS website as `5909-t2.txt` .

Only one star in the CCD-images has a known spectral type (BD $+37^\circ 3937$, Sp G0). The information is obtained from the SIMBAD Astronomical Database (operated at Strasburg, France). Some of our observations outside minima were made in U, B and R bands. Our study has limited a range of a spectral type of the star under investigation from G0 to K2 with high probability.

We see from Fig. 1 that the depths of minima are close to each other. Thus we are dealing with a binary system composed of two stars with similar masses and spectra.

The photometric elements of the system have been derived by minimizing a functional depending on the measured and theoretical magnitude differences (Kozyreva, Zakharov, 2001).

The coefficients of limb-darkening u_1 and u_2 of the component stars (spectral types from $G0$ until $K2$) were chosen according to Grygar et al. (1972) and were fixed during calculations. We found the correlation between the derived photometric elements and the adopted limb-darkening parameters to be rather weak.

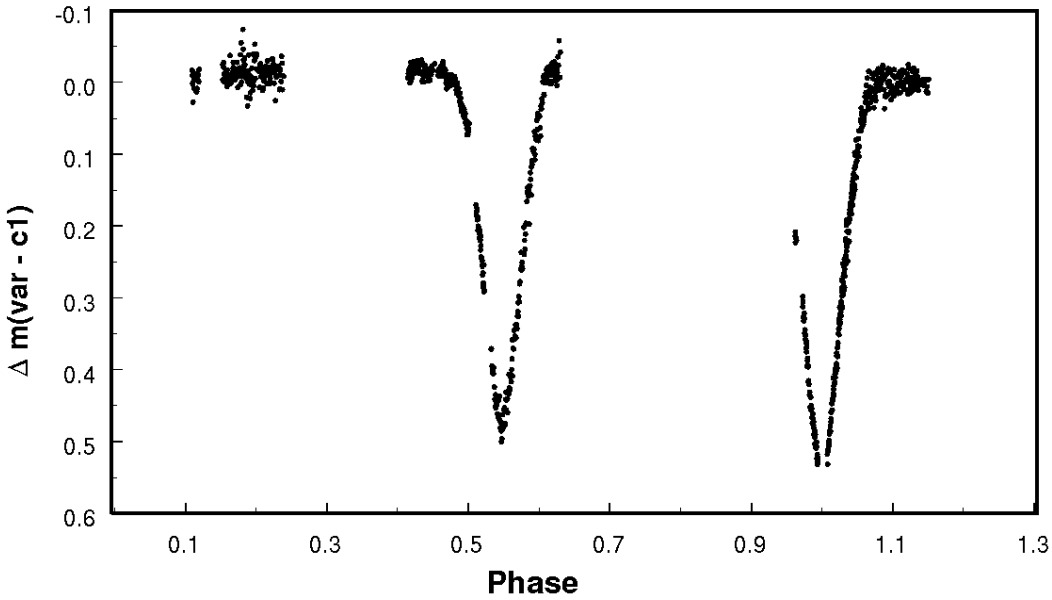

Figure 1. The summary V-light curve of GSC 3152 1202 obtained at the Tian-Shan observatory and at the Crimea observatory in summer 2009

The elements of the system are presented in Tab. 1: the radii (r_1,r_2), inclination (i), the eccentricity (e), longitude of periastron of the orbit (ω), luminosities of the components (L_1,L_2 and the "third light", L_3). In addition the table includes the interval of the fixed limb-darkening parameters (u_1, u_2, according to adopted spectral types of the components), the shift of the secondary minimum ϕ_{II} and the standard deviation (σ_{o-c}) of the solution. The solution corresponds to the average time of our observations (July 2009). Since the light curve is based on a compilation of measurements obtained on different instruments during several months, we expect some systematic errors to be present in the derived photometric elements.

Table 1: The photometric elements of the star GSC 3152 1202.

Element	Value	Element	Value
r_1	0.241 ± 0.003	L_1	0.560 ± 0.020
r_2	0.216 ± 0.005	L_2	0.410 ± 0.020
i	$85\overset{\circ}{.}3 \pm 0\overset{\circ}{.}3$	L_3	0.030 ± 0.030
e	0.084 ± 0.001	u_1	$0.61 \div 0.72$(fixed)
ω	$332\overset{\circ}{.}7 \pm 0\overset{\circ}{.}2$	u_2	$0.61 \div 0.72$(fixed)
ϕ_{II}	$0.^{\rm p}5475 \pm 0.0005$	σ_{o-c}	0.0107

The only available data besides our observations of this star are the time of the primary minimum (JDH 51478.596) and the shift of the secondary minimum ($\phi_{II} = 0.489$) published by Otero et al. (2006).

The change in the phase of the secondary minimum for the two epochs of observations is significant, indicating the existence of apsidal motion of the orbit.

Given the calculated eccentricity $e = 0.084$, the shift of the secondary minimum ($\phi_{II} = 0.489$) agrees with two values of the longitude of periastron located in quadrants II and III. The apsidal period is equal to either 15 or 50 years correspondingly. Thus we can give only the upper limit for the apsidal period: $U \leq 50$ years.

We derived, along with other photometric elements, the time of conjunction of the components at primary eclipse (T_1). The time of secondary conjunction of the components (T_2) was inferred via well-known relation from Kopal (1978) with the derived values of orbital elements (Tab.1):

$$\mathrm{T}_2 = \mathrm{T}_1 + \frac{P}{2} + \frac{2Pe\cos\omega}{\pi} - \frac{2Pe^3(1+3\sqrt{1-e^2})}{3\pi(1+\sqrt{1-e^2})^3}\cos 3\omega + ... \qquad (1)$$

The period P_1 was calculated using two moments of primary minima.

$$\mathrm{Min\,I} = \mathrm{JD}_\odot\, 2455004.4386(2)$$

$$\mathrm{Min\,II} = \mathrm{JD}_\odot\, 2455066.3026(3)$$

$$P_I = 2\overset{\mathrm{d}}{.}093731(1)$$

In conclusion we note that this eclipsing binary system (GSC 3152 1202) is a very good object for rapid detection of apsidal motion.

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