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Period and light-curve study of the contact eclipsing binary V523 Cas

Mahya Mohammadi[a], Abbas Abedi[a,*], Nematollah Riazi[b]

[a] Department of physics, Faculty of science, University of Birjand, Iran and Dr. Mojtahedi observatory, University of Birjand, Iran
[b] Department of Physics, Shahid Beheshti University, Evin, Tehran 19839, Iran

HIGHLIGHTS

- V523 Cas has a pulsating component.
- The new ephemeris and the mass transfer rate of the system is calculated.
- Minimum masses of the third body and the fourth body of the system is estimated.

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ABSTRACT

CCD photometry of the eclipsing W Uma binary system V523 Cas in U, B, V and R_C filters was carried out during eight nights in 2012. The physical and geometrical parameters of this system are obtained. A possible pulsation period of one of the components is obtained by analyzing the residuals of the ephemeris light curve. Our observations contain 16 times of minimum light. We combined these with all available published times of minimum. By fitting a quadratic curve to the O-C values, a new ephemeris of the system is calculated. By attributing the period change to mass transfer, we find a mass transfer rate of $4 \times 10^{-12} \frac{M_\odot}{yr}$. Also, Period (80.58 yr) and the minimum mass (0.3 $M_\odot$) of a possible third body is estimated. In addition, the possible existence of a fourth body with a mass of order 0.15 $M_\odot$ is discussed. These third and fourth bodies could be low-mass main-sequence stars (red dwarfs).

1. Introduction

V523 Cas was found to be an eclipsing binary of W UMa type by Zola et al. (2010). This system is an overcontact binary with one of the shortest known orbital periods ($P = 0.2337$d). Photometric studies began four decades ago by Lavrov and Zhukov (1975). They found its photometric mass ratio (Zola et al., 2010). Times of minimum light were published by Haussler (1974) who classified the system as a W UMa type (Bradstreet, 1981). Hrivnak determined average color indices of the system (Lister et al., 2000). Bradstreet (1981) calculated that it is a contact configuration with a 9% filling factor (Jeong et al., 2006). Milone et al. (1984) determined the first mass ratio spectroscopically and found that $q_{sp} = 0.42 \pm 0.02$. Rucinski et al. (2003) calculated a new spectroscopic mass ratio of $q_{sp} = 0.516 \pm 0.007$ and classified its spectral type as K4V (Zola et al., 2010; Milone et al., 1984; Rucinski et al., 2003). Period variations of V523 Cas have been studied by numerous authors. Lister et al. (2000), Elias and Koch (2000), Shegbang (2001), Zhang and Zhang (2004), Samec et al. (2004) and Kose et al. (2009) have modeled the times of minima (Lister et al., 2000; Elias and Koch, 2000; Shegbang, 2001; Zhang and Zhang, 2004; Samec et al., 2004; Kose et al., 2009).

2. Observations and data reduction

The photometric observations of V523 Cas were obtained with the 14-inch Schmidt-Cassegrain Telescope and SBIG ST-7 CCD camera mounted at the Cassegrain focus at the Mojtahedi Observatory of Birjand University (longitude: 59°26′23.8″, latitude: 32°38′29.3″). Data were obtained in the U, B, V and R_C Johnson–Cousins filters. We observed V523 Cas at 8 nights in August and September 2012. The stars Tyc 3257-1068-1 and Tyc 3257-1326-1 were observed as comparison and check, respectively. Table 1 lists coordinates, magnitudes and colors of V523 Cas and the comparison and check stars.

The observations were reduced using the IRIS software (Buil, 2005). The data for V523 Cas were initially phased with ephemeris of Samec et al. (2004):

$$MinI(HJD) = 2446708.7712 + 0.23369145E \quad (1)$$

3. Light curve solution

We analyzed the light curves of V523 Cas using the PHOEBE software (Prsa and Zwitter, 2005), which is based on the

* Corresponding author. Tel.: +985632436793; +989151608507; fax: 985632202041.
E-mail address: aabedi@birjand.ac.ir (A. Abedi).

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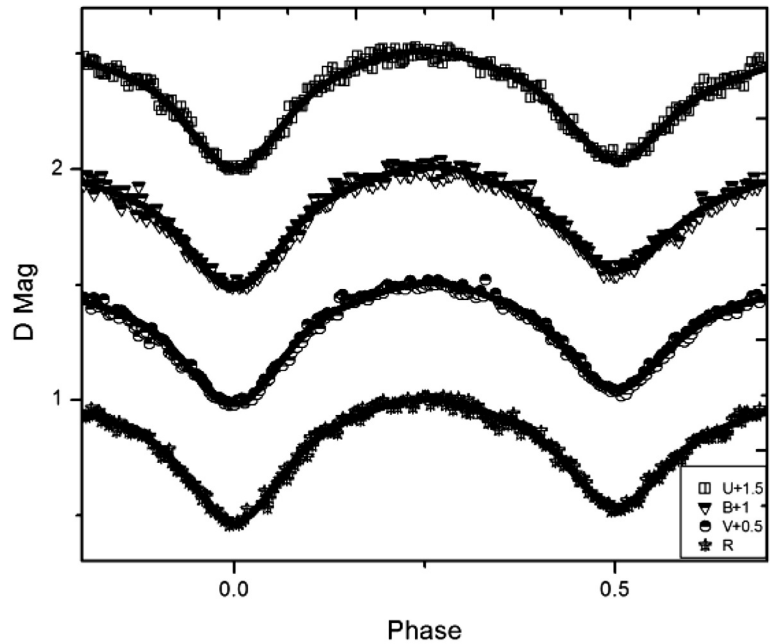

Fig. 1. Observed and synthetic light curves of the V523 Cas in U, B, V and R_C Johnson–Cousins filters. Symbols stand for our observations and solid lines for the calculated light curves.

Table 1
Coordinates and magnitudes of the variable, comparison and check stars.

Star	RA(2012)	Dec(2012)	Magnitude
V523 Cas	0h 40.840 m	50° 18.504′	10.87
comparison	0h 41.137 m	50° 22.136′	11.21
check	0h 41.138 m	50° 24.602′	10.93

Table 2
Starspot parameters.

Filter	*Value*[a]
Longitude	63°
Latitude	39°
Temperature factor	0.7
Spot radius	20°

[a] Based on B–V=1.086 (Samec et al., 2004).

Wilson-Devinney program (Wilson, 1979; Wilson and Devinney, 1971). The best fit was obtained for an overcontact binary of W UMa type. We selected a temperature for the primary star based on its observed B-V obtained in Samec et al. (2004) and then adjusted the temperature of the secondary star. We used limb darkening coefficients according to the Van Hamme software (Hamme, 1993). We fixed the albedo values appropriate for a convective atmosphere. Our

Table 3
Synthetic curve parameters for V523 Cas obtained by different authors.

Parameter	This paper with $T_1 = 5104^oK$[a]	Samec et al. (2004)	Zboril et al. (2006)	Latkovic et al. (2009)
i (deg)	84.355 ± 0.05	85.39 ± 0.11	83.5 ± 0.3	84.8 ± 0.3
$q = \frac{m_2}{m_1}$	0.535 ± 0.003	0.520 ± 0.002	0.520	0.520
$\Omega_1 = \Omega_2$	2.820 ± 0.007	2.822	2.899	2.852
$T_1(^oK)$	5104	5104	4991 ± 12	5176 ± 18
$T_2(^oK)$	5076	4762	4762	4762
$\frac{L_1}{L_1+L_2}$	$U = 0.651$,B $= 0.638$,$V = 0.640$,$R = 0.624$	$V = 0.527$,$B = 0.550$	$V = 0.569$,$R = 0.577$	$V = 0.540$,$R = 0.550$
$\frac{L_2}{L_1+L_2}$	$U = 0.349$,B $= 0.362$,$V = 0.361$,$R = 0.376$			
$A_1 = A_2$	0.5	0.5	0.5	0.5
$g_1 = g_2$	0.32	0.32	0.32	0.32
X_1	$U = 0.6400$,B $= 0.6422$,$V = 0.6410$,$R = 0.6419$	$V = 0.7990$,$B = 0.7990$	$V = 0.6732$,$R = 0.7075$	$V = 0.6743$,$R = 0.7084$
X_2	$U = 0.6358$,B $= 0.6363$,$V = 0.6363$,$R = 0.6363$	$V = 0.7990$,$B = 0.7990$	$V = 0.6565$,$R = 0.7012$	$V = 0.6441$,$R = 0.6985$
Y_1	$U = 0.1673$,B $= 0.1688$,$V = 0.1680$,$R = 0.1686$	$V = B = 0.047$		
Y_2	$U = 0.1569$,B $= 0.1562$,$V = 0.1563$,$R = 0.1562$	$V = B = 0.047$		
$r_1(pole)$	0.4295	0.4263		
$r_1(back)$	0.4987	0.4909		
$r_1(side)$	0.4606	0.4560		
$r_2(pole)$	0.3268	0.3186		
$r_2(back)$	0.3944	0.3793		
$r_2(side)$	0.3450	0.3352		
$\Sigma\omega(o-c)^2$	0.01	0.055	0.1892	0.00914

[a] Based on B–V = 1.086 (Samec et al., 2004). Note: i = orbital inclination, $q = \frac{m_2}{m_1}$ = mass ratio of the components, $T_{1,2}$ = temperature of the primary and secondary component, $\Omega_{1,1}$ = dimensionless surface potentials of the components, $X_{1,2}$, $Y_{1,2}$ = logarithmic nonlinear limb-darkening coefficients of the components, $\frac{L_{1,2}}{L_1+L_2}$ = luminosity of the primary/ secondary star, r = relative radii of the stars in solar units and $\Sigma\omega(O-C)^2$ = final sum of squares of residuals between observed and synthetic light curves.