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V839 Cep - a new massive eclipsing variable with apsidal motion in the field of Trumpler 37

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Abstract. Our precise UBV photometric light curves of a poorly studied Algol-type eclipsing binary V839 Cep were used to derive relative and absolute parameters of the system. The masses of the components 3.3 ± 0.2 $M_\odot$, 4.4 ± 0.3 $M_\odot$, radii 1.9 ± 0.1 $R_\odot$, 2.9 ± 0.1 $R_\odot$, effective temperatures $14150 \pm (300)$ K, $15700 \pm (300)$ K and inclination of the orbit 88.15 ± 0.02 deg were determined. The Eclipse Time Variation (ETV) diagram revealed the apsidal motion in the system with $\dot{\omega}_{obs} = 0.027(9) \mathrm{deg\,yr}^{-1}$, $U = 13600(4500)$ years.

Key words: stars: binaries: eclipsing – stars: binaries: close – stars: interstellar reddening – stars: fundamental parameters

1. Introduction

The eclipsing binary GSC 3964 0741 = V839 Cep ($P = 9.^{\mathrm{d}}96$, $V = 9.65$ mag, $e = 0.11$) was discovered by Otero et al. (2006). The light curve of the system is characterized by the shift of the secondary minimum relatively to the phase 0.5, indicating the ellipticity of the orbit. No photoelectric Light Curves (LCs) of this eclipsing binary have been published yet. The analysis of the observations is complicated by the fact that the eclipsing binary has a bright visual companion ($\Delta V = 1.1$ mag) separated by $0.2''$. Moreover, the main component of the eclipsing binary could be variable.

2. Observations and data reduction

In 2008-2018 we obtained $UBVRI(RcIc)$ photometry of the object with the 0.6-m telescope equipped with a Hamamatsu R2949S photomultiplier, changed later by a G4-9000 CCD at Stará Lesná Observatory (Slovakia) and 1-m and 0.6-m reflectors of Simeiz observatory in Crimea (equipped with CCD FLI PL09000 and VersArray 512UV). The derived colour indices $U - B, B - V$ indicate a

strong interstellar absorption, $E(B-V) = 0.66(1)$, Av = 2.1. The normal colour indices of the star, $(U-B)_0 = -0.61$ and $(B-V)_0 = -0.18$, correspond to the spectral class B4. Although the star is located on the celestial sphere in 4.5 deg from the centre of Trumpler 37 open cluster, which is rich with variable and multiple stars, we found that the object does not belong to it. According to WEBDA (http://webda.physics.muni.cz) the distance of the cluster is 835 pc, much more than 550 pc found in this work. Two editions of Gaia data releases give 370 pc and 714 pc, significantly different from each other and from our estimate, probably due to the fact that the object is visual double.

3. LC solution and absolute parameters

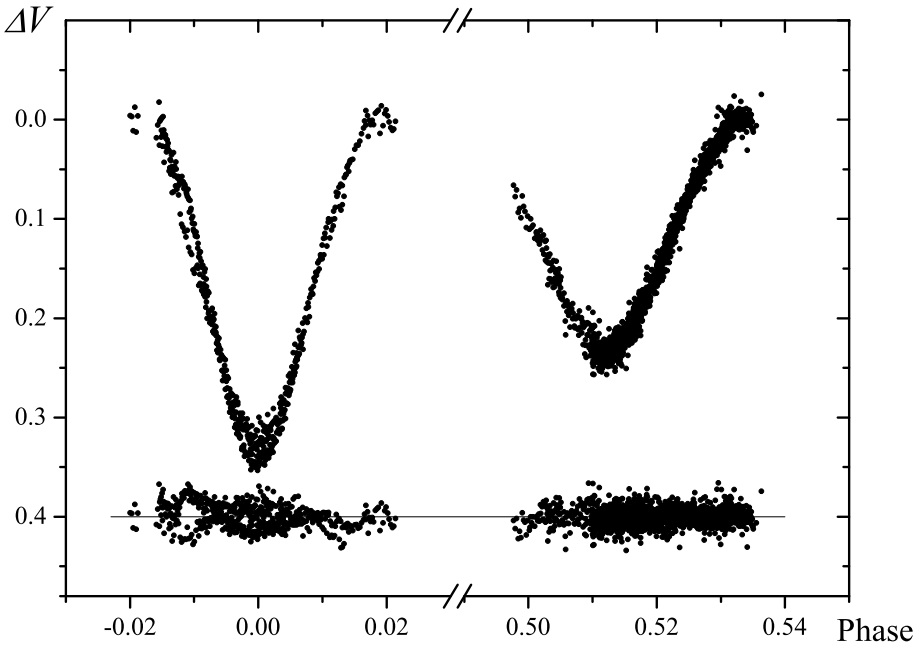

Figure 1. The V observations for V839 Cep. Residuals from the best fit are shown at the bottom of the picture.

The phased LC for the star in the V-band is presented in Fig 1. The observations in $RI(RcIc)$-bands are not completed and will be published in a forthcoming paper. The solution of the LC's were performed by a method described in our previous works on this theme, Volkov & Khaliullin (2002), Volkov & Volkova (2009) is presented in Table 1. We derived the absolute parameters

Table 1. The light curve solution. Parameters of the components: relative radii r_1, r_2, inclination i, eccentricity e, periastron longitude ω, luminosity of main component L_1, third light L_3, limb darkening coefficients u_1, u_2 and error σ.

Parameter	Primary
r_1	0.050 ± 0.001
r_2	0.074 ± 0.001
i (deg)	88.15 ± 0.02
e	0.112 ± 0.003
ω (deg)	80.4 ± 0.8
$L_1 = 1 - L_2 - L_3$	0.267 ± 0.003
L_3	0.269 ± 0.003
$u_1 = u_2$	0.29
σ (mag)	0.0097

of the binary using a non-direct method of Volkov et al. (2017). We derived the temperatures of the components from the $(U - B,\ B - V)$ diagram. We used the Flower (1996) calibration. The results are presented in Table 2.

Table 2. The absolute parameters derived by the non-direct method.

Parameter	Primary	Secondary
M ($M_\odot$)	3.3 ± 0.2	4.4 ± 0.3
R ($R_\odot$)	1.9 ± 0.1	2.9 ± 0.1
$\log g$	4.39 ± 0.04	4.17 ± 0.04
$T(K)$	$14150 \pm (300)$	$15700 \pm (300)$
M_{bol}	-0.47 ± 0.07	-1.77 ± 0.06
d (pc)	550 ± 40	

4. Apsidal motion

We present in Fig. 2 the ETV diagram for the object. We found by a least squares method P1 = $9.^d963364(3)$ and P2 = $9^d.963357(2)$. These values are sufficiently reliable to state that the system demonstrates the apsidal motion: $\dot{\omega}_{obs} = 0.027(9)\,\mathrm{deg\,yr^{-1}}$, $U = 13600(4500)$ years. The theoretical rate of the apsidal motion: $\dot{\omega}_{obs} = 0.021(5)\,\mathrm{deg\,yr^{-1}}$ is close to the obtained value.

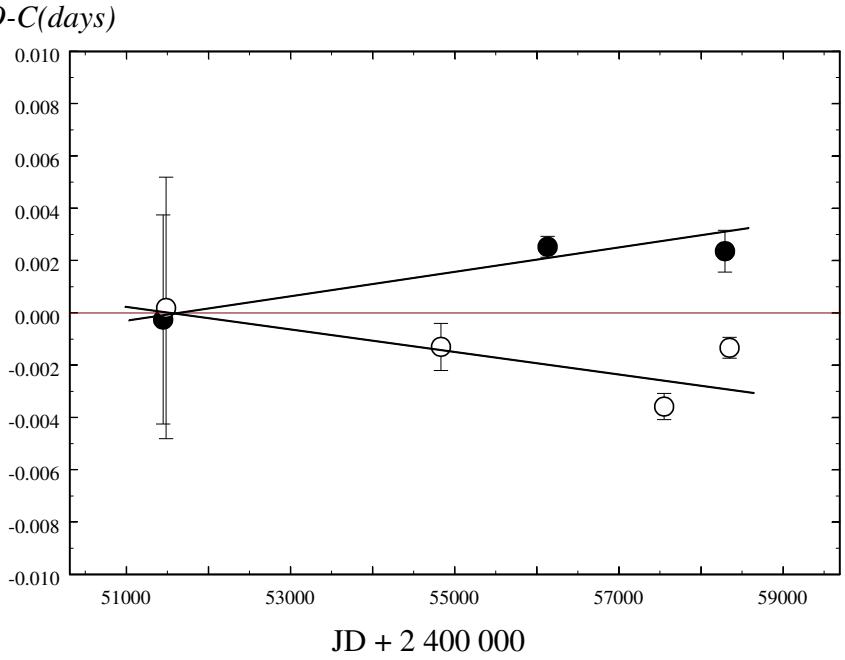

Figure 2. The ETV diagram, constructed with the mean from the P1 and P2 periods for primary (filled circles) and secondary (open circles) minima times. The initial epochs are: Min I=HJD 2451448.6476(21), Min II=HJD 2451483.6403(12).

5. Conclusions

We found the absolute parameters of the components of the eclipsing binary V839 Cep and discovered the apsidal motion in the system. Due to the orientation of the elliptical orbit of the eclipsing star, a more luminous component is eclipsed in the shallow minimum. The analysis was strongly complicated by the physical variability of the dominant (more massive and luminous) component.

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