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Determination of physical parameters of the eclipsing binary V729 Cyg

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Abstract. We report new BVRI photometric observations of an eclipsing, massive binary V729 Cyg taken between 2008 and 2011. We performed light curve modeling of the new data and those available in the literature using the Wilson-Devinney code. The best fit was obtained for a contact configuration, similarly to results derived previously by other investigators. However, a huge temperature difference of about 10 000K - 12 000K was derived, inconsistent with theoretical calculations. Ruling out a possibility of V729 Cyg being a semi-detached system harbouring an accretion disk, we determined physical parameters of components.

Key words: binary stars – eclipsing – fundamental parameters

1. Introduction

V729 Cyg (BD+40°4220, Cyg OB2#5) is an eclipsing binary system, a member of the young stellar association of the OB type. V729 Cyg was discovered to be variable by Miczaika (1953) who assigned it the EB type. The light curve of the system analyzed by Hall (1974) exhibited an intrinsic variability. The results from an analysis of spectroscopic data led Bohannan & Conti (1976) to a conclusion that both components in V729 Cyg are of about the same surface brightness, which is in contradiction to the unequal minima depth observed by Hall and the system mass ratio of $q=4.3$ (the secondary star appears to be too luminous for its mass). Rauw et al. (1999) revised V729 Cyg properties and confirmed the system mass ratio to be high ($q=3.31$, primary to secondary). They also classified the primary component as O6.5-7, suggested the secondary to be of the Ofpe/WN9 type and determined the ratio of components surface brightness to be 1.4 ± 0.6.

Zola et al. (2013) made an attepmt to resolve the problem of the contradictory results concerning the temperatures of the components and their surface luminosity ratio by introducing a semidetached geometry and an accretion disk. As the result, they concluded that, for such a high mass ratio, there is no room for a stationary disk to be present in V729 Cyg.

2. New Photometric Observations and the Results from Light curve modeling

Between December 2008 and February 2011 we preformed new photometric observations of V729 Cyg using the 60 cm telescope at the Mt. Suhora observatory, the 50 cm telescope at the Jagiellonian University observatory in Krakow and the 50 cm telescope at the Astronomical Observatory of Canakkale University. All three telescopes are equipped with CCDs and a set of wide band UBVRI filters. GSC 3161 1269 and GSC 3161 1384 were used as the check and comparison stars, respectively. Our new observations also show significant intrinsic variability, but negligible difference of the heights of the maxima.

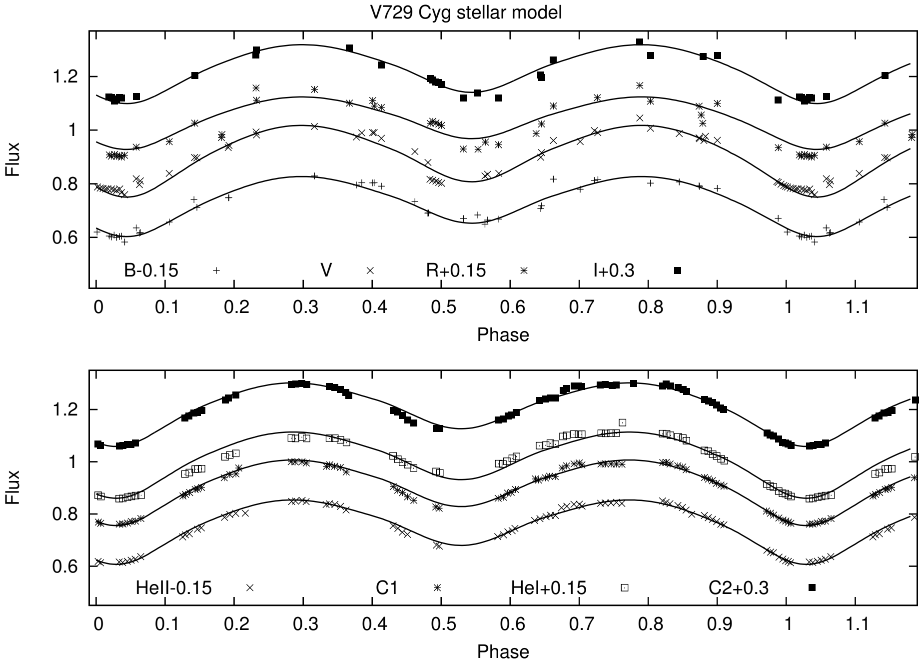

Figure 1. Comparison between theoretical and observed light curves of V729 Cyg. Dots represent individual observations, theoretical light curves are shown as continuous lines. New BVRI data are shown in the top panel while the Linder's data in the bottom one.

We performed a light curve solution of the new data (five most deviant points have to be discarded) and used the light curves in He II and He I lines and continuum (c1 and c2 filters) published by Linder et al. (2009). The modeling was done with the Wilson-Devinney (W-D) code (Wilson & Devinney 1971), appended with the Monte Carlo search algorithm, separately for the two sets of data. Based on spectroscopic results, we fixed the temperature of the primary at 36 000 K and the mass ratio at its spectroscopic value. The limb darkening coefficients were taken from the Claret & Bloemen (2011) tables. V729 Cyg is a quadruple system and therefore a third light was also an adjusted parameter. We found out that for both sets of data the contact configuration (with fill factors of 35% and 18% for new BVRI data and Linder's data, respectively) fits observations best. In order to reproduce observations well, it was required that the difference between the temperature of components is large (reaching 12 000 K), in contradiction to theories of common envelopes. The comparison between theoretical and observed light curves is shown in Fig. 1.

Based on the results derived from the light curve modeling and the spectroscopic values of radial velocity semiamplitudes, we calculated the absolute system parameters:

$$M_1{=}31.3{\pm}2.5,\ M_2{=}8.8{\pm}1.4,\ R_1{=}25.5{\pm}0.9 \text{ and } R_2{=}14.320{\pm}0.535$$

(given in solar units and mean values calculated from Linder's and new data). Finally, we made an additional search for possible solutions, assuming either a hot or a cool region to be present on the surface of the secondary. If a model with a cool spot, placed on the surface of the secondary is considered, the best fit within such a model results in only about 2000 K temperature difference. The longitude of the spot was about 160° and its maximum influence on the light curve shape is at the secondary minimum phases. Similar results were obtained by Linder et al. (2009), but in their solution a hot spot was located on the side of the secondary facing the primary component. Some of our spotted solutions converged to a near contact configuration. Their quality was somewhat worse than the contact one but, due to high intrinsic variability of the light curve, a near contact or a semidetached configurations of V729 Cyg cannot be excluded.

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