

PHOTOMETRICAL STUDY OF OVERCONTACT BINARY SYSTEM V859 Cyg

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ABSTRACT. We present the results of photometrical research of close binary system V859 Cyg with possible period variations. The light curve of the star was constructed using *V*-band magnitudes, obtained in 2007, 2009, 2014 years in Kalinenkov Astronomical Observatory of Nikolaev National University (Nikolaev, Ukraine). According our full light curve both eclipses are partial, the depths of primary and secondary minima in *V*-band are $0^m.38$ and $0^m.32$ respectively. We found 9 new time minima. However, the standard ephemeris of primary eclipse corresponds to our secondary minimum and vice versa during all observational seasons.

We obtained the parameters of binary system from light curve using Binary Maker 3 package. The inclination of orbit of V859 Cyg system is $64.^\circ5$. The temperatures of components are $T_{effI} = 7100K$, $T_{effII} = 6850K$ and mass ratio is 0.35. Both components are deformed by mutual gravity and overflow own Roche lobes, fillout factor is 0.875 for both stars. Mean radii of components are 0.51 and 0.33 of distance between stars. We attributed V859 Cyg as overcontact system with stable period $0.^d4050066$.

Key words: Stars: eclipsing: close binary stars: individual: V859 Cyg.

1. Introduction

Eclipsing binary system V859 Cyg ($RA_{2000} = 19^h27^m12^s.7$, $DEC_{2000} = +28^\circ56'50''$, $V_{max} = 11^m.7$, $V_{min} = 12^m.2$, $JDH_{minI} = 2434629.4141 + 0.40500132E$, *EW/KW*-type) according to GCVS database (Samus et al., 2012) was described as variable by Wachmann (1963). We include the star V859 Cyg in our program of observations as scantily explored close binary system with possible period variations. The program stars were selected from 1140 eclipsing binaries with period variations, collected by Kreiner

et al. (2000). The results of the investigation of some program binaries such as CU Peg, V609 Aql, BM UMa and V841 Cyg were published (Panko et al., 2006, Turner et al., 2008, Virnina et al., 2010, Sergienko et al., 2013). *O-C* diagram for V859 Cyg according to Kreiner et al. (2000) included only 17 time minima, but suggest some systematic period variations. In the “Up-To-Date Linear Elements of Eclipsing Binaries” (Kreiner, 2004) the 15 new time minima of the star were added and updated elements was calculated: $HJD_{minI} = 2452500.0759 + 0.4050066E$. The full set of time of minima collected in the “Variable Star and Exoplanet Section of the Czech Astronomical Society” database (*O-C* Gateway) includes 75 time minima and their *O-C* values according elements $HJD_{minI} = 2434629.4141 + 0.4050019E$. The full light curve of V859 Cyg was obtained in “The First INTEGRAL/OMC Catalogue of optically variable sources” (Alfonso-Garzon et al., 2012). From Optical Monitoring Camera (OMC) onboard INTEGRAL data they found the period of V859 Cyg, videlicet 0.40501036 with error 0.000017. However, full light curve of the star was not analyzed.

2. Observations

The observational data were obtained using the 70-cm telescope ZTS-702 of AOK, equipped with a SBIG ST-7 camera in an instrumental photometric system closely approximating the standard *V*-band. The focal length of the telescope is 2.806 *m* and CCD-frame corresponds to $5' \times 8'$ sky area. V859 Cyg was observed in July of 2007, 2009 and 2014. Frames were taken with 60 and 90 *sec* exposure time, *S/N* ratio for variable was in limits 14 – 45. The standard reduction included dark signal and flat field correction was executed for all frames. Barycentric Julian Dates (*HJD*) were calculated using Eastman et al. (2010) code. We carried out the aperture photometry realized in the MUNI-

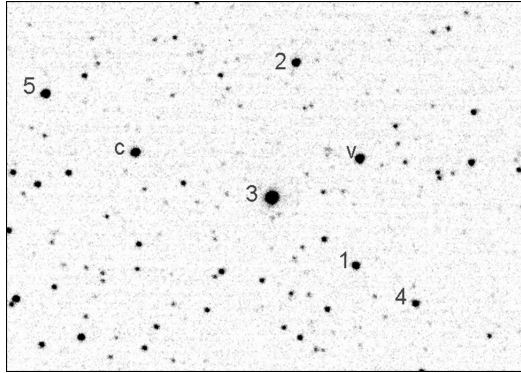


Figure 1: The reference stars in V859 Cyg frame.

Table 1: The reference stars for V841 Cyg frame.

| N | TASS 4 | V | SD |
|-----|---------|------------|-----------|
| c | 1839447 | $11^m.901$ | $0^m.101$ |
| 1 | 1839414 | 12.840 | 0.178 |
| 2 | 3488546 | 12.471 | 0.112 |
| 3 | 3136596 | 9.709 | 0.058 |
| 4 | 3136587 | 13.500 | 0.332 |
| 5 | 1839453 | 11.915 | 0.099 |

PACK software (Motl, 2003-2012). The package allows to determine the difference in magnitudes between comparison, control and variable stars. We assumed equal air mass for all stars in our small frames. The background has been estimated from neighboring pixels. The SD for individual relative magnitudes was not worse $0^m.040$. The reference stars were found in the TASS Mark IV photometric catalog, version 2 (Droegge et al., 2007). The positions of variable, comparison and 5 control stars are shown in Fig. 1; the magnitudes and TASS Mark IV number of the stars are placed in the Table 1. The observed and synthetic light curves are shown in Fig. 2. The new time minima and their $O-C$ according to elements from $O-C$ Gateway are placed in the Table 2. The full light curve allows as to determine the depths of primary and secondary minima and to reconstruct of the system parameters. Our $O-C$ values are in good agreement with Kreiner (2004) elements, but with 0.5-period correction, as it shown in Fig. 2. Note, modern set of observations gives linear dependence in $O-C$ variations.

3. Light curve analyze and discussion

From the analysis of V859 Cyg light curve we obtained $\Delta m_I = 0^m.38$, $\Delta m_{II} = 0^m.32$ in V -band. The $B - V$ values of V859 Cyg varies from 0.1 (Hog et al.,

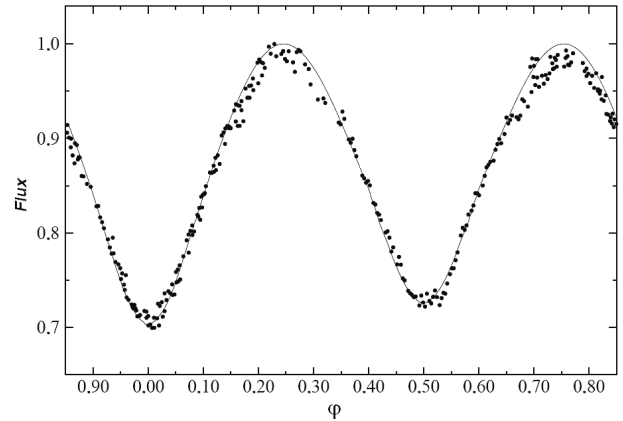


Figure 2: The light curve solution for V859 Cyg. Observational data are marked as dots, our final solution curve is line.

2000) to 0.224 (Kharchenko, 2009) and we assumed an initial effective temperature for the primary $T_{effI} = 7600K$. We modeled the light curve for V851 Cyg using Binary Maker 3 and *Catalog and Atlas of Eclipsing Binaries* (CALEB <http://caleb.eastern.edu/>) along with reasonable estimates for the properties of the two components. The temperature of the secondary of V859 Cyg was established through analysis of the light curve. The final solution was chosen in model grids calculated with steps: 0.01 in mass ratio and Ω -potentials, 50K in temperature and 0.25° in inclination. The linear limb darkening coefficients were assigned according to van Hamme (1993) as 0.598 for both components taking into consideration the final temperatures.

Table 2: V859 Cyg new time minima.

| HJD_I | HJD_{II} |
|---------------|---------------|
| 2454288.38378 | 2454291.42123 |
| 2454292.43403 | 2455033.39398 |
| 2455019.41972 | 2455041.49424 |
| 2455034.40568 | 2456868.47254 |
| 2456867.45999 | |

The best solution implies $T_{effI} = 7100K$ and $T_{effII} = 6850K$, mass ratio 0.35, mean radii of components are 0.51 and 0.33 of distance between stars. Both eclipses are partial and inclination of V859 Cyg system is $64.^\circ5$. Both components are deformed by mutual gravity and overflow own Roche lobes: fillout factor is $+0.875$ for both stars. The system reconstruction on phase 0.25 is shown in Fig. 3. We attributed V859 Cyg as overcontact system. In *A Catalogue of Approximate Photometric and Absolute Elements of Eclipsing Variable Stars* (Svechnikov & Kuznetsova, 1990) V859 Cyg is W UMa system with mass ratio 0.39 and inclination $73.^\circ5$. Spectra SP1+SP2 are (F1)+[F2],

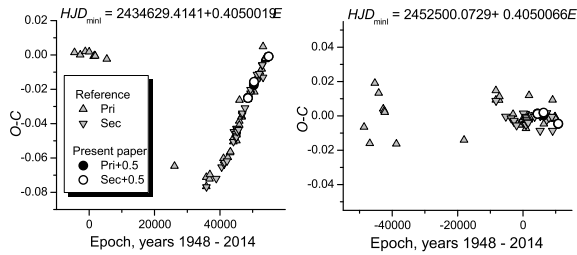


Figure 3: $O-C$ variations of V859 Cyg system in 1948–2014 according to $O-C$ Gateway (left panel) and Kreiner (2004) elements.

and radii of the components 0.465 and 0.265 of the distance between stars. The data for V859 Cyg in the Catalogue by Svechnikov & Kuznetsova (1990) based on the GCVS and reference data have accuracy remark 1 in (0–9 scale), i.e. rough. Our reconstruction of the system improves the parameters of V859 Cyg.

4. Conclusion

From three seasons of observations we obtained 9 new time minima for W UMa type binary V859 Cyg. We found the positions of the primary and secondary minima of the light curve are checked on the 0.5 of period, so elements HJD_{minI} corresponds to secondary minima. The depths of minima in V-band are for primary $0^m.38$ and for secondary $0^m.32$. The inclination of orbit of V859 Cyg system is $64.^\circ5$. The temperatures of components are $T_{effI} = 7100K$, $T_{effII} = 6850K$ and mass ratio is 0.35. Both components are deformed by mutual gravity and overflow own Roche lobes, fillout factor is 0.875 for both stars. Mean radii of components are 0.51 and 0.33 of distance between stars. We attributed V859 Cyg as overcontact system. The elements $HJD_{minI} = 2452500.0729 + 0.4050066E$ (Kreiner, 2004) give the best value of the period without systematical variations, but describe the secondary minima times.

Acknowledgements. This research has made use of NASA’s Astrophysics Data System. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. E. Panko is thankful to professor D. Turner and Saint Mary’s University, Halifax, Canada for support of this research.

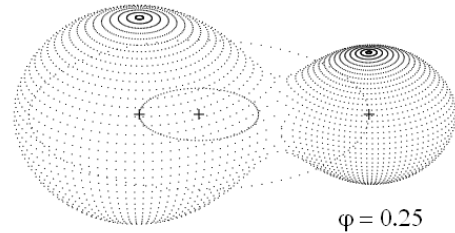


Figure 4: The view of reconstructed V859 Cyg system in phase 0.25.

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