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Structural changes in DPVs related to the long cycle

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Abstract. Recent studies indicate changes in the morphology of the light curve of OGLE-LMC-DPV-097 directly related to the long cycle. These are explained by changes in the structure of the accretion disk and temperatures of the bright and hot spot. In this report we present a preliminary study of a new galactic DPV, OGLE-BLG-ECL-157529, that has similar behavior.

Key words: binaries: eclipsing - stars: close - binaries.

1. Introduction

Double periodic variables (DPVs) are a sub-class of Algol binary systems. They exhibit two photometric cycles: an orbital period, typical of eclipsing binaries, and a long cycle of unknown origin. The latter lasts in average about 33 times the orbital period (Mennickent et al., 2003). Studies indicate that a B-type star (gainer) surrounded by an accretion disk with a late-type giant star (donor) filling its Roche lobe are the components in DPVs systems (Mennickent et al., 2016). Previous research shows that the donor is a potentially magnetic active star, as is the case of the DPV V393 Sco (Mennickent et al., 2012; Mennickent, Schleicher & San Martin-Perez 2018). Possibly the accretion flow is modulated as a result of a magnetic dynamo cycle, where the radius of the donor changes, as shown in Applegate models (Schleicher & Mennickent, 2017).

Recently we reported a change in the light curve morphology of DPV-097 (see Garcés et al., 2018). Now we present a new DPV in the bulge of the Milky Way with similar behavior. OGLE-BLG-ECL-157529 (I = 13.035, α=17:53:08, δ=-32:46:27), has an orbital period of 24.7991558 $\pm$ 0.000202 [d] and a variable long period that descends from 867 to 742 [d] in the photometric time series (15 years) taken from the OGLE-II/III/IV project data bases (provided by the OGLE team) and described by Soszyński et al., 2016. We disentangled the light curve into an orbital and long-cycle using the Fourier decomposition algorithm described by Mennickent et al., 2012.

Table 1. Results of the analysis of ECL-157529 considering the OGLE II light curves. * Results from Garcés et al., 2018 for DPV-097. A comparison of both objects can be visualized.

	OGLE-LMC-DPV-097*				OGLE-BLG-ECL-157529			
Quanty	**Asc***	**Max***	**Des***	**Min***	**Asc**	**Max**	**Des**	**Min**
$\Sigma(O-C)^2$	0.0481	0.0464	0.1662	0.1692	0.1662	0.0481	0.1692	0.0464
i [°]	74.3	75.1	74.4	74.4	85.20	85.44	85.13	85.40
T_d [K]	4030	5580	5210	6870	3460	4550	3675	3670
T_h [K]	14000	14000	14000	14000	18630	18750	18760	18740
T_c [K]	4930	4980	4910	4950	6650	6650	6650	6650
$A_{hs} = T_{hs}/T_d$	1.63	1.70	1.14	1.71	1.78	1.67	1.20	1.81
$A_{bs} = T_{bs}/T_d$	1.78	1.17	1.16	1.76	1.51	1.52	1.81	1.58
$M_{\rm h}\,[M_\odot]$	5.51	5.51	5.51	5.51	7.26	7.26	7.26	7.26
$M_{\rm c}\,[M_\odot]$	1.10	1.10	1.10	1.10	1.45	1.45	1.45	1.45
$R_{\rm h}\,[R_\odot]$	3.65	3.64	3.65	3.65	4.95	4.95	4.92	4.91
$R_{\rm c}\,[R_\odot]$	7.75	7.75	7.75	7.75	18.44	18.44	18.44	18.44
$R_{\rm d}\,[R_\odot]$	15.28	15.40	11.20	7.49	34.34	34.14	35.94	32.69
$\rm d_e[R_\odot]$	1.36	1.06	2.53	0.95	6.65	2.95	2.65	6.99
$\rm d_c[R_\odot]$	3.09	3.41	3.16	2.60	3.38	2.22	5.15	10.40

Fixed Parameters: $q = M_{\rm c}/M_{\rm h} = 0.20$ mass ratio, temperature of one component. **Quantities:** $\Sigma(\rm O-C)^2$ sum of squares of residuals between observed and synthetic light curves, i orbit inclination. $\rm T_d$, $\rm T_c$, $\rm T_h$ temperature of the disk-edge, donnor (Cooler) and gainer (Hotter) respectively. $\rm A_{hs}$, $\rm A_{bs}$ hot and bright spots temperature coefficients. $M_{\rm h}$, $M_{\rm c}$, $R_{\rm d}$, $R_{\rm h}$, $R_{\rm c}$ stellar masses and mean radii of disk and stars in solar units. $\rm d_e$, $\rm d_c$, disk thicknesses (at the edge and at the center).

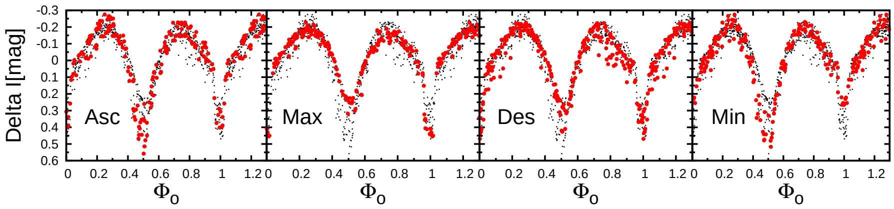

Figure 1. Black dots represent the disentangled orbital light curve of OGLE-157529. Red dots represent the same but at different branches of the long cycle (See Sec. 2).

2. Model

For OGLE-157529, the long cycle phases (ϕ_l) are defined using a constant long period of 867 [d] and considering only OGLE II I-band data (See Fig. 1), where the ascendent (Asc) branch corresponds to $0.6 < \phi_l \leq 0.9$, maximum (Max) to $0.9 < \phi_l \leq 1.1$, descendent (Des) to $0.11 < \phi_l \leq 0.35$ and Minimum (Min) to $0.35 < \phi_l \leq 0.60$.

We applied theoretical models to the light curve on the different branches of the long cycle using a program developed by Djurašević (1992a, 1992b). Our models assume an optically and geometrically thick disk with a radial temperature profile that follows the distribution proposed by Zola (1991), synchronous rotation for both stellar components and q = 0.2 based on complete studies performed on differents DPVs (Mennickent, Otero & Kołaczkowski, 2016).

3. Conclusion

We found changes in the light curve of OGLE-157529 related to the different stages of the long cycle. As for our previous study in DPV-097, this could be explained mainly by structural changes of the accretion disk and the temperatures of the hot and bright spot. The most significant change for OGLE-157529 is the disk thickness, while for DPV-097 is the disk radius (See Table 1).

The OGLE database allows us to investigate for the first time this type of phenomena on DPVs and a complete study of this interesting object is in preparation.

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References

Djurašević, G.,: 1992a, *Astrophys. Space Sci.* **196**, 267

Djurašević, G.,: 1992b, *Astrophys. Space Sci.* **197**, 17

Garcés L., J., Mennickent, R., Djurašević, G., et al.,: 2018, *Mon. Not. R. Astron. Soc.* **477**, L11

Mennickent, R.E., Pietrzyński, G., Diaz, M., et al.,: 2003, *Astron. Astrophys.* **399**, L47

Mennickent, R.E., Djurašević, G., Kołaczkowski, Z., et al.,: 2012, *Mon. Not. R. Astron. Soc.* **421**, 862

Mennickent, R. E., Otero, S. and Kołaczkowski, Z.: 2016, *Mon. Not. R. Astron. Soc.* **455**, 1728

Mennickent, R.E., Schleicher, D.R.G., San Martin-Perez, R.,: 2018, *Publ. Astron. Soc. Pac.* **130**, 094203

Schleicher, D. R. G. and Mennickent, R. E.: 2017, *Astron. Astrophys.* **602**, A109

Soszyński, I., Pawlak, M., Pietrukowicz, P., et al.,: 2016, *Acta Astron.* **66**, 131

Zola, S.: 1991, *Acta Astron.* **41**, 213