Eccentric Eclipsing Binaries: Tests of General Relativity

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Abstract The study of apsidal motion in detached eclipsing binary systems with eccentric orbits is known as an important source of information for stellar internal structure as well as for the possibility of verification of general relativity outside the Solar System. Suitable objects for this research were collected by Giménez and Crawford (1994). In this paper we report a summary of our results on the observational status of three eccentric binaries with longer periods, namely V541 Cygni, EW Orionis, and GG Orionis, and we appeal to photometrists with moderate or small telescopes around the world to observe these binaries.

1. Observations of minimum light

Our photometric observations of V541 Cyg, EW Ori, and GG Ori were performed mostly at the Ondřejov Observatory, Czech Republic, during the period from 1993 to 1997. A 65-cm reflecting telescope with a SBIG ST-6 CCD camera in the primary focus was used. The measurements were done primarily using the standard Cousins *R, V* filters. Several local comparison stars were present in each frame, allowing differential photometry also during non-photometric sky conditions. The photometric reduction of the series of CCD frames was performed using APHOT, synthetic aperture photometry software developed by M. Velen and P. Pravec at Ondřejov Observatory (Pravec *et al.* 1994).

2. Apsidal motion analysis

The apsidal motion of V541 Cyg, EW Ori, and GG Ori was studied by means of an *O–C* diagram analysis (for details see, e.g., Wolf *et al.* 1996, 1997). The derived apsidal motion parameters—period *P*, orbital eccentricity *e*, longitude of the periastron ω_0, and observed rate of apsidal motion $\dot{\omega}_{obs}$—are given in Table 1. The last column presents the relativistic contribution to the apsidal motion $\dot{\omega}_{rel}$ computed according to Giménez (1985). The system V541 Cyg was discussed also by Wolf

(1995) and Guinan *et al.* (1996). More details on EW Ori were presented recently in Wolf *et al.* (1997).

3. Conclusions

Our results indicate that the rate of apsidal motion in these three systems is extremely slow—indeed, significantly slower than the theoretically expected relativistic contribution. Similar anomalous cases which exhibit the discrepancy between observed and predicted rate of the apsidal motion, such as DI Her or AS Cam, were carefully discussed in the past. More high-accuracy timings of these eclipsing systems are necessary to enlarge the time span for better analysis of the apsidal motion. We appeal to photometrists with moderate or small telescopes around the world to monitor these binaries. For the present, we propose the linear light elements given in Table 2.

References

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Table 1. Orbital elements of selected eccentric binaries.

Star	*Period days*	*e*	ω_0 $^\circ$	$\dot{\omega}_{obs}$ $^\circ yr^{-1}$	$\dot{\omega}_{rel}$ $^\circ yr^{-1}$
V541 Cyg	15.3379	0.474	263	:0.0053	0.0082
EW Ori	6.9368	0.057	327	<0.0001	0.0140
GG Ori	6.6315	0.126	197	<0.0001	0.0253

Table 2. Light elements.

Star	*Primary Min. HJD 2400000*	*Secondary Min. HJD 2400000*	*Period days*	*Reference*
V541 Cyg	44882.2127	44889.2192	15.337873	Khaliullin (1985)
EW Ori	50497.3691	50147.2694	6.936842	Wolf *et al.* (1997)
GG Ori	49717.6624	50098.4571	6.631498	this paper