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Observational Manifestations of Changes in the Orbits of Some Triple Systems

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Abstract. In this presentation we describe some of the observable manifestations of the long-term influence of third bodies on the parameters of eclipsing binaries, using as examples some of the objects we are currently observing.

It has become apparent that some of the light curves of even long-period eclipsing systems can be subject to significant changes. Two prominent examples are SS Lac (P = 14.4 days; Mossakovskaya 1993) and QX Cas (P=6.0 days; Guinan 2012), in which the eclipses have gone away. The only plausible explanation for such a significant change in the system is the presence of an unseen wide companion perturbing the orbit of the inner eclipsing binary. In the course of our investigation of eclipsing systems with significant eccentricity we regularly find changes in the light curves, though not as dramatic, which could be also explained by the presence of a third body.

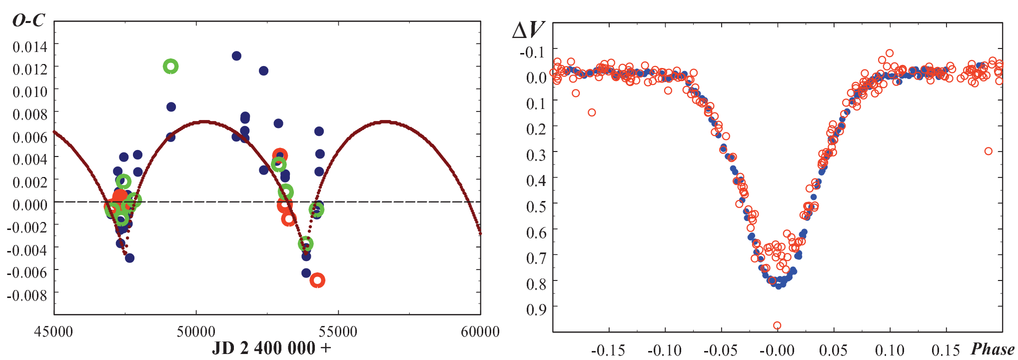

Figure 1.: *Left:* $O-C$ diagram (days) for V577 Oph. Blue circles correspond to δ Sct maxima, red circles to times of primary eclipse, and green circles to times of secondary eclipse. The brown line represents the theoretical fit for a proposed third body orbit. *Right:* Folded light curve of DX Vel near the primary minimum. Blue points are the van Houten observations (van Houten 2009), and red circles are based on ASAS data (Pojmanski 2002).

The most common way of detecting third bodies is by means of the $O-C$ diagram constructed from the eclipse timings (see Figure 1, left). But very often we first find features in the light curve that can be also ascribed to an external influence. In the case of V577 Oph we first found that the star becomes redder during both minima (Volkov 1990). Only much later did we notice the light-time effect in the eclipse timings and the pulsations of the main component (Volkov & Volkova 2010), as shown in Figure 1 (left). A similar behavior in the colors and the changes in the depth of the primary minimum (Figure 1, right) led us to postulate the presence of a third body in DX Vel. Recent observations of this object seem to support this idea (Volkov et al. 2013). In the V974 Cyg system we first detected periodic changes in $O - C$ diagram, and only then did we suspect that the colors in both minima are slightly redder (Volkov & Volkova 2011).

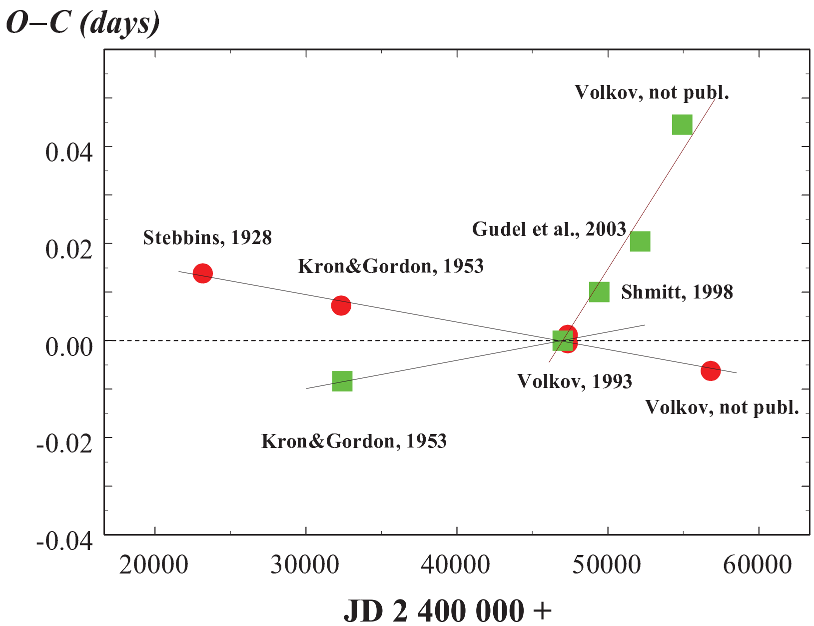

Figure 2.: The $O - C$ plot for α CrB, with red circles for the primary minima and green squares for the secondary. The plot is based on the average of the P_1 and P_2 periods that operated until 1989 (the break point in the secondary timings), and pointed to the slow apsidal motion in the system (Volkov 2005).

Table 1.: Parameters of α CrB derived from the light curves obtained at different epochs (mean wavelengths indicated). The parameters that change with time are indicated in bold font.

Parameter	1947-48 723 nm	1987-89 750 nm	1987-89 460 nm	2008-14 ≈750 nm
i (deg)	**88.01(1)**	**88.09(1)**	**87.98(1)**	**88.31(1)**
ω (deg)	314.2(1)	310.9(1)	–	309.1(1)
e	**0.35(1)**	**0.37(1)**	–	**0.39(1)**
r_1	0.072(1)	0.069(2)	0.069(2)	0.068(1)
r_2	0.021(4)	0.020(1)	0.021(1)	0.020(1)
σ (mag)	0.0052	0.0043	0.0052	0.0051

An interesting behavior in the $O - C$ diagram is illustrated by the bright eclipsing binary α CrB, with a period P = 17.36 days (Figure 2). It can be seen that while the primary minima display a linear behavior, the trend of the secondary minima shows a break. One possibility is that the system has a third component, the effect of which is a tentative increase seen in the eccentricity and inclination of the system (see Table 1). A similar possibility was explored by Khodykin et al. (1991) for the case of DI Her.

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