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Eclipsing binaries in the ASAS survey

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Abstract. We present a statistical investigation of eclipsing binaries presented in the ASAS [1] survey. Applying the Fourier analysis on the ASAS light curves, we used the relations between coefficients to infer principal properties of eclipsing binaries. The systems with eccentric orbits were found and for the same sample the minimum eccentricity was estimated. We also selected short-period detached eclipsing binaries suitable for the detection of circumbinary exoplanets. Systems with the equal minima depth were also discussed.

Key words: ASAS database – Fourier coefficients – circumbinary exoplanets

An effective way to quickly classify an eclipsing binary star is to perform the Fourier decomposition of its phase light curve (hereafter LC, see Rucinski, 1973). In a general case, one can represent phase dependence of the intensity by the following trigonometric polynomial:

$$S(x) = \frac{a_0}{2} + \sum_{n=1}^{k} [a_n \cos(2\pi nx) + b_n \sin(2\pi nx)], \qquad (1)$$

where x is the orbital phase and k is a degree of the polynomial.

A LC of an eclipsing binary can be asymmetric with respect to phase 0.5 in two cases: (i) the orbit is eccentric (the phase of the secondary minimum is shifted with respect to phase 0.5, Fig. 1 top-left) (ii) maxima are of different heights and the LC is distorted (the O'Connell effect - see Davidge & Milone, 1984; Pribulla et al., 2011, Fig. 1, bottom). The latter possibility is usually interpreted by the presence of photospheric spots, or streams of matter between the components.

Asymmetric LCs were searched for in the ASAS database by the following approach. First, the original phased LC was subdivided into 20 phase bins. Standard deviation, σ, of the LC was determined from deviations of individual points from the mean value in each bin. Then the datapoints flipped around phase 0.5 were added to the original data, giving σ^*. The LC asymmetry was then assessed from the ratio of the standard deviations, $p = \frac{\sigma^*}{\sigma}$. To single out the systems with asymmetric LCs, we set the limit rather arbitrarily to $p = 1.6$.

[1] http://www.astrouw.edu.pl/asas/?page=download

Out of 5500 tested LCs, 120 showed significant asymmetry. Out of 20 eccentric systems identified from the LC asymmetry (other LCs were either with the O'Connell effect, or they were symmetrical with high noise), 10 are found to be eccentric binaries from the ASAS data for the first time. An example of the system with an eccentric orbit is shown in Fig 1 (top-left).

According to the sign of the Fourier coefficient b_1 we can say which maximum is higher than the other one (Fig 1, bottom). For the negative sign of this coefficient one can see that the maximum after the primary minimum is higher in comparison with the maximum after the secondary minimum and vice versa.

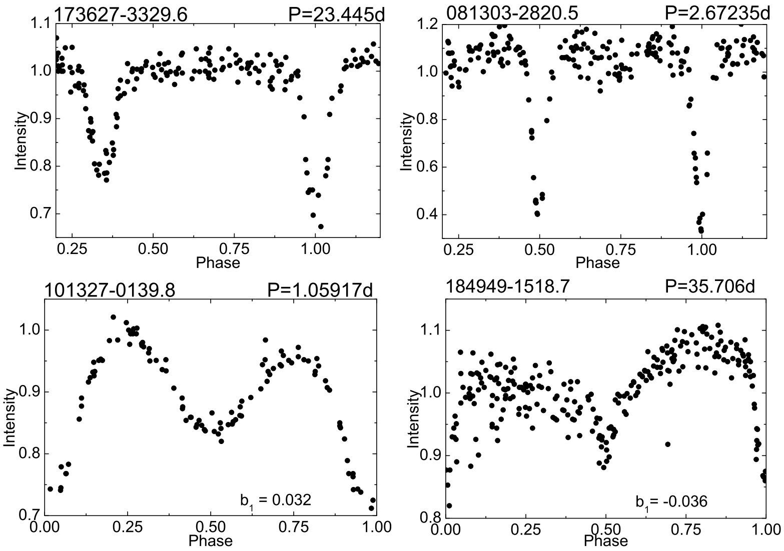

Figure 1. The sample of LCs from the ASAS database. The upper left figure shows the LC of the system with an eccentric orbit, upper right one shows the LC with the same depths of minima. Plots at the bottom show two LCs with the O'Connell effect having different signs of b_1.

Many LCs of binary systems have the same depths of the primary and secondary minima within the error of the photometry. This can occur in the following cases: (i) The depths of the primary and secondary minima are indeed equal (Fig. 1 (top-right)). For systems with a circular orbit this means that the temperatures of the components are also equal. (ii) The secondary minimum was not detected by the ASAS photometry. Then the true orbital period is half of the catalog value. In the latter case the system is (i) eccentric with an inclined orbit or (ii) the secondary is a cold late-type dwarf component (or a brown dwarf).

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