13 NEW ECLIPSING BINARIES WITH ADDITIONAL VARIABILITY IN THE ASAS CATALOGUE

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Abstract. We present 13 new ASAS eclipsing binaries that exhibit additional periodic variability due to pulsations, eclipses with another period or spots. All contact and semi-detached binaries from the ASAS Catalogue were investigated.

The All Sky Automated Survey has already collected over 6 years of observations for the majority of the sky (declinations < +28 deg), down to 14th magnitude. Semi-automatic classification of variable stars resulted in the ASAS Catalogue of Variable Stars - ACVS (Pojmański et al. 2006). For details on the classification procedure see Pojmański (2002). A big part of ACVS consists of eclipsing binaries, among them are 5,384 contact (EC), 2,957 semidetached (ESD), and 2,758 detached (ED) binaries. Recently a sub-sample of these has been searched for period changes (Pilecki et al. 2007). During this investigation a side analysis was performed which resulted in 16 (13 new) binaries which are suspect to additional periodic behaviour of various origin; secondary variability may be due to spots, pulsations, or second eclipsing binary in the system. Two of them, namely 115143-6253.2 and 164802-6715.2, were found by D. Fabrycky, who pointed out (private comm.) that these stars showed eclipses with another period.

The search for second periodicity was performed on residual light curves of all EC and ESD binaries in ACVS (8,341 objects). After detecting an additional frequency for each object, all the light curves were sorted by amplitude of the frequency and the ones with a significant signal strength were inspected visually. This left us with 14 objects for which (together with additional two stars mentioned above) a more detailed analysis was performed.

In order to separate the light curves for both kinds of variability we applied an iterative method. In the first step the best fitting model of an eclipsing binary $M_1$ with orbital period $P_1$ was removed from the original light curve. Then we analysed the residual light curve in the search for secondary period $P_2$, which was used to construct the model $M_2$ of additional variability. This model was then subtracted from the original light curve and the residual light curve was again investigated to find a refined $M_1$. After subtracting the
new $M_1$ from the raw light curve, the new $M_2$ was once again determined. In some cases one more step was performed to get a better model $M_1$.

Using residual light curves of models $M_1$ and $M_2$, variability was then classified with periods $P_1$ and $P_2$ using the same procedure as in Pojmanski (2002). However, all pulsating types were combined into one PULS category and, when it was plausible, we changed automatic classification to "Spot" type.

Table 1. ASAS eclipsing binaries exhibiting additional periodic variability.

| ASAS ID  | $V_{max}$ [mag] | $P_1$ [days] | Type | $P_2$ [days] | Type | Blend | Other | Other ID |
|----------|-----------------|--------------|------|--------------|------|-------|--------|----------|
| 174848-5004.5 | 7.45 | 7.71215 | ESD | 233.4 | PULS | 0 | 0 | B1III | V393 Sco |
| 153713-1820.1 | 8.35 | 6.86170 | ESD | 6.87811 | Spot | 0 | 0 | K1II X | IV Lib |
| 101309-5005.7 | 10.50 | 0.953397 | ESD | 1.11070 | ESD=ED | 2 | 1 | F | HD 302992 |
| 172736-3808.5 | 11.50 | 0.373603 | ESD | 0.423350 | EC/PULS | 2 | 2 | — | — |
| 115143-6525.2 | 9.93 | 0.876114 | ESD | 19.11(x2) | ED | 2 | 1 | B5 | BV 729 |
| 164802-6715.2 | 10.43 | 0.422509 | EC=ESD | 1.59378 | ED/ESD | 2 | 2 | — | TYC 9050-298-1 |
| 144001-1059.5 | 10.00 | 0.354445 | EC=ESD | 0.334349 | ESD/EC | 0 | 1 | G0.X | BD-19 3931 |
| 003501-5044.1 | 9.61 | 21.1405 | EC/ESD | 21.1067 | Spot | 1 | 0 | K1,X | CD-52 646 |
| 125523-7322.2 | 9.74 | 206.1 | EC | 250.2 | 1 | 1 | — | TYC 9253-1392-1 |
| 105153-1206.5 | 11.43 | 0.384647 | EC | 0.353901 | ESD/EC | 0 | 0 | — | — | |
| 131055-4844.1 | 10.80 | 7.06562 | EC? | 3.53721 | Spots? | 2 | 0 | — | — | |
| 103308-7133.4 | 10.58 | 0.816199 | EC | 0.388607 | ESD=ED | 0 | 0 | — | TYC 9219-3329-1 |
| 190004-2741.4 | 12.24 | 0.439555 | EC | 0.537903 | ESD/EC | 2 | 2 | — | V395 Sgr |

In Table 1 we listed both periods ($P_1$ and $P_2$), separate variability types and the possible degree of blending (0 for none, 1 for small and 2 for large) listed in two columns, designated by I and A. The first one (I) is the degree of blending evaluated subjectively by an examination of higher resolution images from Digitized Sky Survey, whereas A is the result of brightness comparison in different apertures of ASAS photometry. The radius of the smallest aperture is 1 pixel and for the largest 3 pixels, so two faint stars close to each other are separated when using small aperture and counted as one object when using a large aperture, significantly increasing the brightness. Some additional information from the SIMBAD database is given (if available) such as an other identifier, spectral type, and whether the star might be an X-ray source (X).

Two stars were found in the WDS catalogue of astrometric doubles and multiples (Mason et al. 2001). 234520-3100.5 was identified as a double star (11.58 mag + 11.94 mag) with a separation of 1” and 125523-7322.2 (10.6 mag + 11.5 mag) with a separation of 2.4”.

In the course of this analysis 7 out of 13 objects turned out to be double eclipsing binaries (ie. quadruples that consists of two doubles), whereas one exhibits additional pulsations; for one object both scenarios are probable. There are also two stars whose secondary periods have values close to that of primary periods. This kind of behaviour is believed to be due to spots on one of the binary’s components. For the remaining two we have no plausible explanation.

Table 2. Objects examined independently by Pigulski & Michalska.

| ASAS ID  | 2nd type | Blend | Other |
|----------|----------|-------|-------|
| 182323-1240.9 | PULS | 2 | 0 | FR Sct |
| 234520-3100.5 | EC/PULS | 0 | 0 | — |
| 084350-4007.2 | ESD/EC | 2 | 2 | ALS 1135 |
Figure 1. Two examples of double periodic behaviour. Original and residual light curves are shown.
The light curves of other stars are attached at the end of this paper in a simplified form.
Three stars listed in Table 2 were independently found and recently analysed by Pigulski & Michalska (2007a,b). They found FR Set to be a triple VV Cephei-type system, 234520-3100.5 to show additional δ Scuti behaviour, and 084350-4607.2 to exhibit β Cephei-type variations. For them we quote only our second variability type and an estimation of a degree of blending.

One star, namely 131055-4844.0, has a secondary period value close to (but not the same as) half the value of the primary variation period. Moreover, a residual light curve of the second variability has an eclipsing-like shape with two minima of different depth. This cautions, that the primary period may be two times smaller and the primary variability may be due to pulsations rather than eclipses.

All presented stars need a further study. Spectroscopic and photometric observations of higher resolution will help to determine a true nature of these objects.

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Figure 2. Light curve of 153713-1820.1.

Figure 3. Light curve of 172738-3808.6.
Figure 4. Light curve of 115143-6253.2.

Figure 5. Light curve of 164802-6715.2.
Figure 6. Light curve of 144001-1959.5.

Figure 7. Light curve of 031509-5144.2.
**Figure 8.** Light curve of 125523-7322.2.

**Figure 9.** Light curve of 103513-1206.5.
Figure 10. Light curve of 131055-4844.0.

Figure 11. Light curve of 103308-7133.8.
Figure 12. Light curve of 190004-2741.4.