

# Period Doubling and Modulation of Pulsation in Type II Cepheids from the OGLE Collection

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We report the initial results of the analysis of type II Cepheids' photometry collected by the OGLE project. New cases of period doubling in BL Her and W Vir-type variables are reported. Examples of a quasi-periodic modulation of the pulsation in BL Her variables, akin to the well-known Blazhko effect, are reported for the first time.

We have analysed OGLE-IV *I*-band photometry for type II Cepheids of the Galactic bulge (Soszyński et al., 2017). We have searched for dynamical phenomena such as period doubling and periodic modulation of the pulsation. Our analysis followed a standard consecutive prewhitening technique. In the frequency spectra prewhitened with the fundamental mode frequency and its harmonics,  $kf_0$ , we searched for additional lower-amplitude signals.

In the time domain, period doubling manifests as alternating deep and shallow brightness minima/maxima. In the frequency domain, the effect manifests as signals centered at sub-harmonic frequencies,  $(n + 1/2)f_0$ . It is a characteristic feature of the longest-period subgroup of type II Cepheids, the RV Tau class. Interestingly, the effect was also predicted to occur in the shortest-period subgroup, BL Her stars (Buchler & Moskalik, 1992), and was indeed discovered in the OGLE data (Smolec et al., 2012). Pulsation models of Smolec (2016) show that period doubling may occur in all subgroups of type II Cepheids: BL Her, W Vir, and RV Tau stars.

Periodic modulation of pulsations' amplitude and phase is characteristic for a significant fraction of RR Lyrae stars and is called the Blazhko effect. In the frequency spectrum, it manifests as equidistant multiplets centered at the pulsation frequency and its harmonics,  $kf_0 \pm lf_m$  ( $f_m$  – modulation frequency), as well as signals in the low frequency range,  $nf_m$ , corresponding to the modulation of mean brightness. Pulsation models of Smolec & Moskalik (2012) and Smolec (2016) predict that the periodic modulation of pulsation may also occur in type II Cepheids.

Period doubling was detected in three BL Her-type stars, OGLE-BLG-T2CEP-279, -257, and -820. Only the last star represents a new discovery, the former two were already known (Smolec et al., 2012). Only in T2CEP-279 the effect is robust and of relatively large amplitude. In the other two stars, the effect is of very low amplitude and of transient nature – it is present in some observing seasons only.

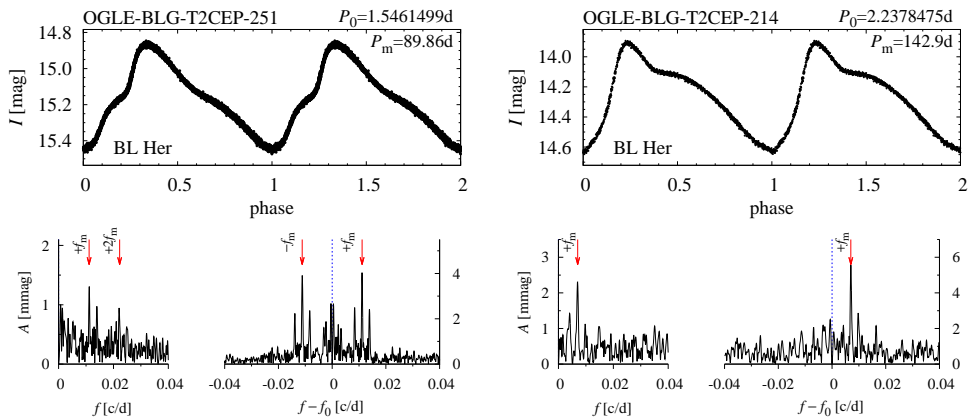


Fig. 1: Light curves (top panels) and frequency spectra (bottom panels) for two modulated BL Her-type stars: T2CEP-251 (left panels) and T2CEP-214 (right panels). For both stars, frequency spectra are zoomed at the low frequency range or are centered at  $f_0$ . The dashed line marks the location of the prewhitened fundamental mode and the arrows indicate modulation side peaks. For T2CEP-214, side peaks at  $f_m$ ,  $f_0+f_m$  and  $2f_0+f_m$  (not shown) were detected.

Period doubling was also detected in more than 20 W Vir stars with pulsation periods between 15 and 20 d, so at the transition between the W Vir and RV Tau classes. For other examples of period-doubled W Vir stars, see Plachy et al. (2017) and Plachy et al., these proceedings.

The most important and interesting discovery is the detection of the quasi-periodic modulation of pulsation in more than 20 type II Cepheids, in agreement with theoretical predictions. Exemplary light curves and frequency spectra of two BL Her-type stars are plotted in Fig. 1. Interestingly, in both stars, and in the majority of other modulated type II Cepheids, the mean brightness is also modulated.

Detailed results of this analysis will be published elsewhere (Smolec et al., in prep.).

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## References

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