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Light-curve changes over the Blazhko cycle in RR Lyrae stars

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Abstract. We present the on-line gallery of animations illustrating light-curve changes over the Blazhko cycle in RR Lyrae stars.

In an ongoing project we search for the Blazhko effect in fundamental mode RR Lyrae stars (RRab) and analyse its properties. We use the data from the fourth phase of the Optical Gravitational Lensing Experiment (OGLE, Udalski et al. 2015) for the Galactic bulge RR Lyrae stars (Soszyński et al. 2014). Full results of our survey will be presented elsewhere. Here we focus on the light-curve variation over the modulation cycle, which we study with the help of the Fourier decomposition parameters and animations. We first select the stars which show a fairly regular Blazhko cycle and have good coverage of all phases of the modulation[1]. Our analysis is a standard consecutive prewhitening technique, which allows one to find pulsation period, P_0, and modulation period, $P_{\rm B}$, the latter from the separation of multiplet components (Fourier representation of the modulation). We determine some basic properties of the modulation, like parameters characterizing the triplet asymmetry, $R = A_+/A_-$ and $Q = (A_+ - A_-)/(A_+ + A_-)$, where A_+ and A_- refer to the amplitude of the higher and lower frequency triplet components, respectively (see e.g., Guggenberger et al. 2012). These parameters may be calculated at each harmonic order; here we provide their values only for the triplet at the fundamental mode frequency.

Animations are done in the following way. First, we fold the OGLE data with the modulation period. The resulting modulation curve is divided into 40 phase bins, each 0.05-wide (with 0.025 overlap). For each bin, data are folded with the pulsation period and fitted with the Fourier series. The low-order decomposition parameters, R_{21}, R_{31}, φ_{21} and φ_{31}, are calculated. These data form a base for a single frame of the animation. The on-line gallery may be found at the following URL: `http://users.camk.edu.pl/smolec/blazhko/`.

The page starts with a table of the form illustrated in Table 1, with basic data about the stars. Each animation consists of two panels. In the left panel the light curve folded on the pulsation period and its change over the modulation cycle are displayed. The blue curve is a Fourier fit to the extracted fundamental mode light curve, i.e. light curve with all the multiplet components filtered out. Note it is not the same as Fourier fit to the mean light curve (all data folded on the pulsation period). For the right panel one can choose among several options,

[1]It is not easy task. Additional very low amplitude modulation or periodicities may be present in the discussed stars. See 'remarks' column in Table 1. These signals will be discussed elsewhere.

each showing the Fourier parameter variation in different planes, e.g. R_{21}-A_1, φ_{21}-A_1, R_{21}-φ_{21}, etc. The open diamond corresponds to the Fourier parameters of the mean light curve, while filled diamond corresponds to Fourier parameters of the extracted light curve (modulation filtered out). A snapshot from one of the animations is illustrated in Fig. 1.

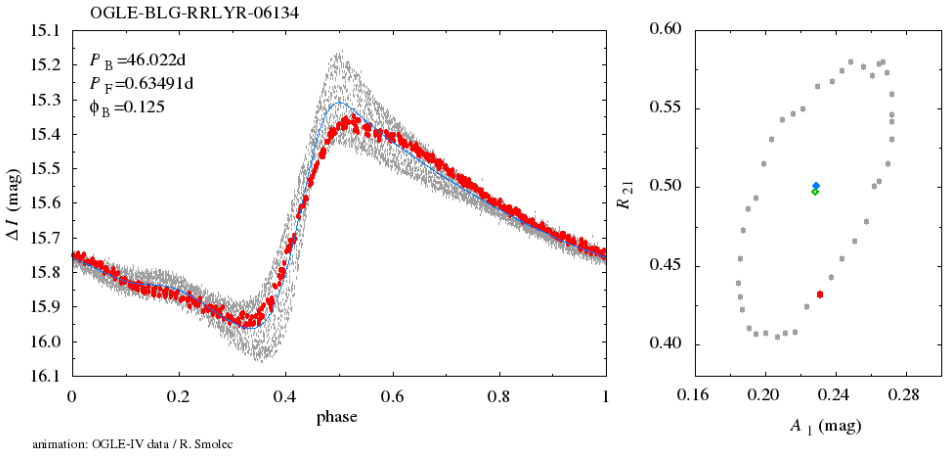

Figure 1. A snapshot from one of the animations, illustrating light-curve changes over the Blazhko cycle.

Table 1. Basic data for analysed stars: star's ID, pulsation and modulation periods, pulsation and modulation amplitudes, A_1 and $\max(A_+, A_-)/A_1$, asymmetry parameters, R and Q, and remarks ('1O' – first overtone detected, 'mod' – other periodicity detected, 'HIF' – periodicity close to half-integer frequency detected, 'BL+' – additional low-amplitude modulation detected). The full table is available on-line.

ID	P_0 (d)	P_B (d)	A_1 (mag)	A_m/A_1	R	Q	remarks
OGLE-BLG-RRLYR-06134	0.634907	46.02	0.229	0.135	0.57	−0.27	
OGLE-BLG-RRLYR-07576	0.618626	121.77	0.127	0.160	2.82	0.48	
OGLE-BLG-RRLYR-09450	0.483470	78.16	0.243	0.154	0.94	−0.03	1O, HIF
...							

We observe a diversity in the light curve changes over the Blazhko cycle. Fourier parameters follow the diverse loop patterns. Detailed analysis and conclusions will be presented elsewhere.

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References

Guggenberger, E., Kolenberg, K., Nemec, J. M., et al. 2012, MNRAS, 424, 649
Soszyński, I., Udalski, A., Szymański, M. K., et al. 2014, Acta Astron., 64, 177
Udalski, A., Szymański, M. K., Szymański, G. 2015, Acta Astron., 65, 1