

# Period Doubling Effect in Blazhko Modulated RRc Star from OGLE-IV Survey?

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We report a possible detection of a period doubling effect in the Blazhko RRc star, OGLE-BLG-RRLYR-06097, from the OGLE-IV survey data. Successive pre-whitening analysis results in a frequency peak at half-integer of the radial mode, indicating period doubling. However, the amplitude of the signal is too low to observe any manifestation directly in the light curve. We also present frequency analysis of *Kepler* observations of KIC 4484128, which is a well-established modulated fundamental mode RR Lyrae star with period doubling effect, to show the correspondence with our candidate.

## 1 Introduction

RR Lyrae stars are known to exhibit quasi-periodic modulation of pulsation amplitude and phase known as the Blazhko effect (Blazhko, 1907). A century has passed since its discovery but its cause still remains to be a mystery. In recent years, another dynamical effect, known as period doubling, was observationally established in the Blazhko-modulated fundamental-mode RR Lyrae (RRab) stars. In the light curves, it is manifested by alternating maxima over pulsation cycles (see, e.g., Fig. 6 of Szabó et al., 2010) and in the frequency domain as peaks at half-integer frequencies of the radial mode. In the model proposed by Buchler & Kolláth (2011) both phenomena are connected and caused by the 9:2 resonance between the fundamental mode and the 9<sup>th</sup> overtone mode; see Kolláth (2021) for detailed discussion of this model.

Hence, it is natural to investigate, if a similar mechanism operates in the Blazhko first overtone RR Lyrae (RRc) stars as well. The detection of period doubled modulated RRc star may support this idea.

## 2 Results

Our candidate, OGLE-BLG-RRLYR-06097, was identified as the Blazhko RRc star by Netzel et al. (2018). Its OGLE-IV photometry data (Soszyński et al., 2019b) consists of 8 seasons of observation spanning  $\sim 3000$  days (see Fig. 1). Frequency analysis gives the first overtone mode with a period of 0.25387870(4) d. We compare the estimated Fourier parameters  $R_{21}$ ,  $\varphi_{21}$ ,  $R_{31}$  and  $\varphi_{31}$  with literature Magellanic and Galactic fields sample (Soszyński et al., 2014, 2019a) and indeed find them consistent with the RRc star classification (see Fig. 2). In the frequency analysis, after pre-whitening the peaks corresponding to the radial mode and its harmonics, side peaks around the radial mode corresponding to the Blazhko modulation of 12.4456(5) d are revealed. The overall frequency solution obtained is listed in Tab. 1.

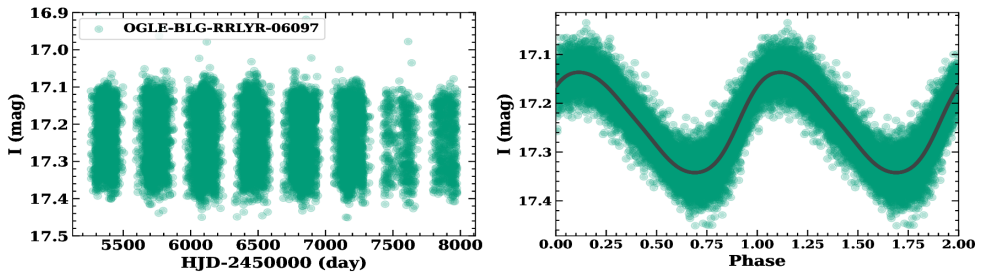


Fig. 1: OGLE-BLG-RRLYR-06097: Photometry data (*left*) and phased light curve (*right*).

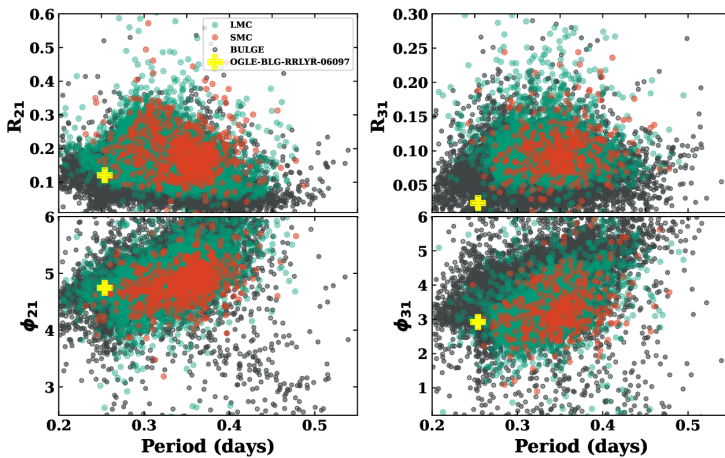


Fig. 2: Comparison of Fourier parameters of OGLE-BLG-RRLYR-06097 with literature RRc stars.

After pre-whitening the data with modulation side peaks, a few additional peaks appear which neither have any radial interpretation nor are due to the Blazhko modulation. In this step, we detect frequency peaks around half-integer of the first overtone radial mode (see Fig. 3). Some of the low-frequency peaks had slightly higher S/N compared to the half-integer peak, but none of them corresponded to an alias of our subharmonic peak, hence the indicating it may correspond to a real signal. In Fig. 3 we show our candidate's correspondence with the *Kepler* star KIC 4484128 (V808 Cyg) which is a confirmed period-doubled Blazhko RRab star (Szabó et al., 2010). It has a fundamental mode period of 0.5478721(8) d and Blazhko period of 90.2(3) d. We applied the same pre-whitening analysis procedure to KIC 4484128 and can clearly see the subharmonic peak in its frequency spectrum as well.

### 3 Conclusions

OGLE-BLG-RRLYR-06097 is modulated RRc star that shows a presence of low-amplitude half-integer peak of the radial mode in the frequency spectrum, which is indicative to period doubling effect. Since the effect is of low-amplitude and the frequency spectrum contains additional, close, low-amplitude signals, further

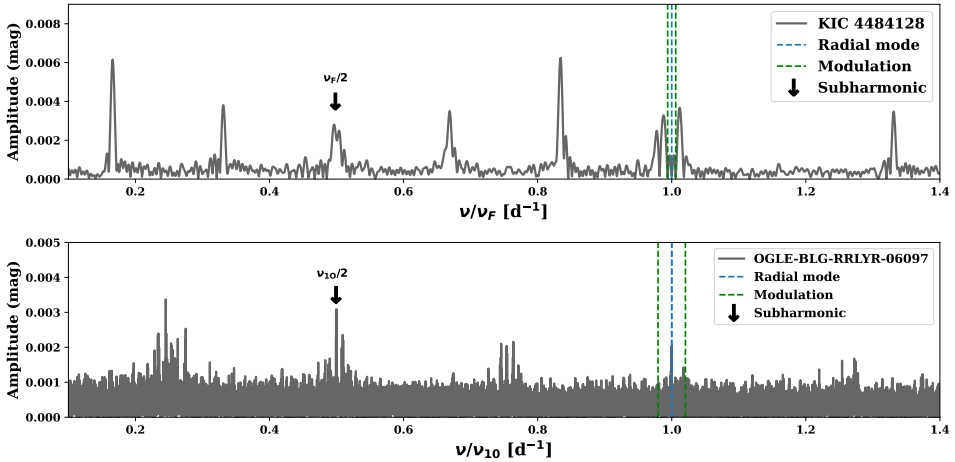


Fig. 3: *Top*: Comparison star KIC 4484128 showing subharmonic peak in the frequency spectra. *Bottom*: Similar subharmonic peak seen in the frequency spectra of OGLE-BLG-RRLYR-06097 after pre-whitening.

Tab. 1: Frequencies and their amplitudes obtained from the analysis of OGLE-BLG-RRLYR-06097 provided to the last significant digit.

Frequency ( $\text{d}^{-1}$ )	Amplitude (mag)	Interpretation
3.93888876	0.1036	$\nu_{10}$
4.01923832	0.0162	$\nu_{10} + \nu_m$
3.85853919	0.0115	$\nu_{10} - \nu_m$
7.87777752	0.0131	$2\nu_{10}$
7.95812708	0.0043	$2\nu_{10} + \nu_m$
7.79742795	0.0026	$2\nu_{10} - \nu_m$
11.81666628	0.0027	$3\nu_{10}$
11.89701584	0.0013	$3\nu_{10} + \nu_m$
15.75555503	0.0017	$4\nu_{10}$
1.96888084	0.0031	$(\nu_{10})/2$

observations are needed to confirm the effect. The presence of period doubling effect in a modulated RRc star may indicate that, similar to RRab stars, half-integer resonance may play a role in driving the modulations of RRc stars.

*Acknowledgements.* This research is supported by the Polish National Science Center project Sonata BIS 2018/30/E/ST9/00598.

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