

Shockwave Behaviour in RR Lyrae Stars

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Here we present the detailed analysis of some modulated *Kepler* and *K2* RR Lyrae stars that show peculiar bump progression in respect to the pulsation phase.

1 Introduction

Observations of RR Lyrae stars in the *K2* mission revealed a peculiar bump progression in respect to the pulsation phase in some modulated RR Lyrae stars. The apparent, unexpected shifts in the occurrence of the bumps (the signatures of shockwaves in pulsating stars) raise the question whether these objects are RR Lyraes at all. We present the detailed analysis of light curves extracted by Extended Aperture Photometry (EAP; Plachy et al., 2017; Still & Barclay, 2012) to search for additional differences from the “ordinary” Blazhko stars. We found four stars in the *K2* fields and another one in the original *Kepler* frames that show modulations similar to those of V445 Lyr (Guggenberger et al., 2012). The peculiar bumps always appear near the Blazhko minima, whereas the light curves become sinusoidal. These shockwaves propagate forward or backward with respect to the pulsation phase depending on the instantaneous pulsation phase at the time of emergence, respectively.

2 Shockwave Behaviour of EPIC 206072581

Fig. 1 and 2 show the light curve, Fourier spectrum, and the variation of the Fourier-coefficients, respectively, of EPIC 206072581 as an example of the behaviour of the shockwaves. In this case, the bump that appears at the maximum brightness of the pulsation migrates downwards. During this, the R_{21} amplitude ratio decreases to ~ 0.05 , while the epoch-independent phase differences do a counterclockwise loop (increasing phase difference). In the Fourier spectrum, the amplitudes of some harmonics of the secondary peak are higher than the one between f_0 and $2f_0$. This can be a consequence of overlap with a higher frequency variation.

3 Petersen Diagram

Additional peaks found between the fundamental modes and its first harmonics are plotted in a Petersen diagram (adopted from Molnár et al., 2017, Fig. 3). Only two weird RR Lyraes show the sign of period doubling, while the presence of the Blazhko modulation is unambiguous in the light curves. Three stars contain peaks around first overtone and four of them around the second overtone. Are all these excited modes radial or can they be non-radial as well?

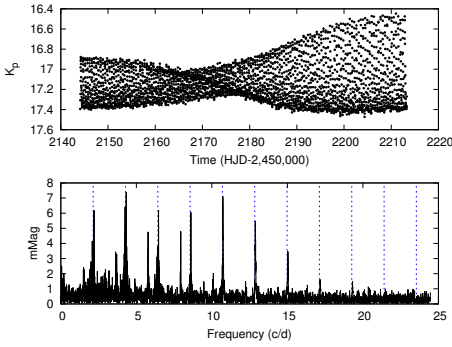


Fig. 1: Light curve (top) and Fourier-spectrum (bottom) of EPIC 206072581.

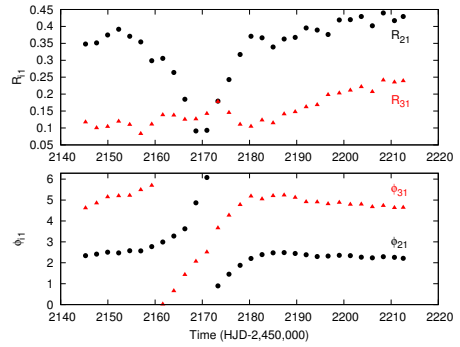


Fig. 2: Time variation of the R_{21} , R_{31} and ϕ_{21} , ϕ_{31} Fourier-coefficients.

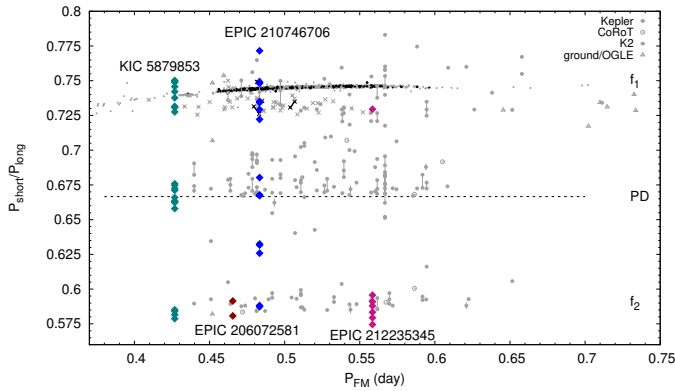


Fig. 3: The position of the peaks found between the fundamental mode and its first harmonics in the Petersen diagram.

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