On the extreme period change of the RR Lyrae variable BE Dor

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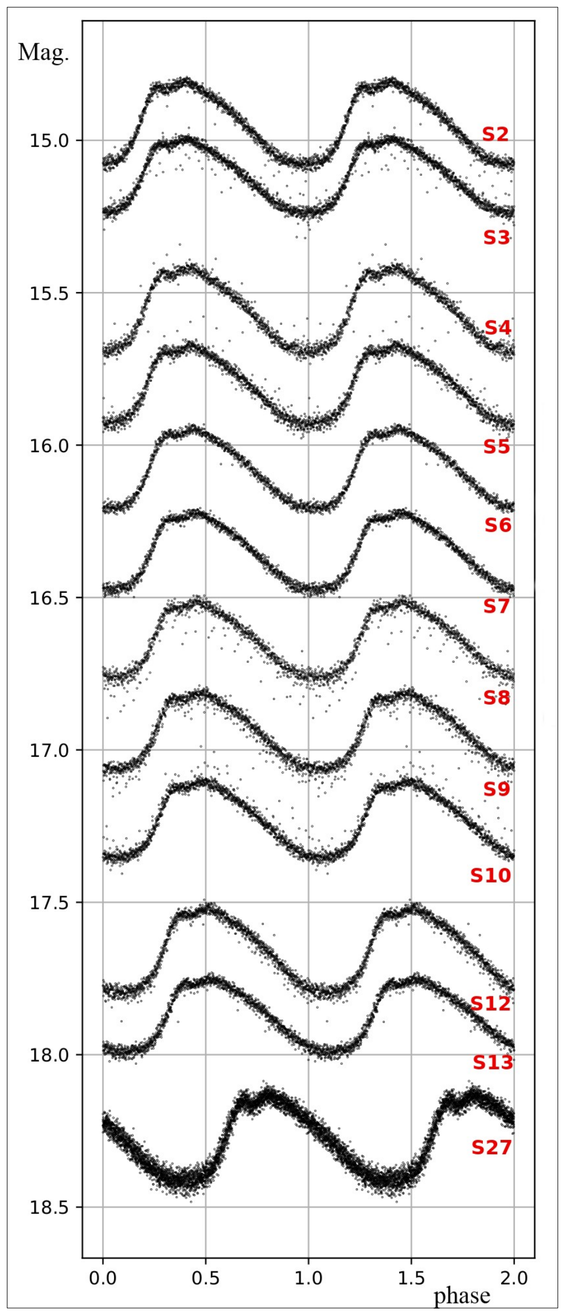

Figure 1. *The phase folded light curve of BE Dor observed by TESS. The labels indicate the sector numbers.The phase shift is very prominent.*

Introduction

The unique period variation of BE Dor was discovered by Derekas et al. (2004) when analysing variable stars observed by the MACHO project. BE Dor (previously known as MACHO*J050918.712-695015.31) turned out to be a foreground object of the Large Magellanic Cloud at V∼15 mag. It is a first overtone RR Lyrae pulsator with a pulsation period of 0.328 d and amplitude of 0.5 mag in the MACHO blue band.

Derekas et al. (2004) performed a detailed study of the object. While the light curve shape remained very stable during the 12 year long dataset available then, they found a rapid, cyclic period modulation with the cycle length of about 8 yrs. They also discussed the possible causes of this enormous period change. If it was caused by light time effect, the minimum mass of the companion should be about 60 M_{sun}, which is a very unlikely configuration. Another possible cause can be hydromagnetic effects.

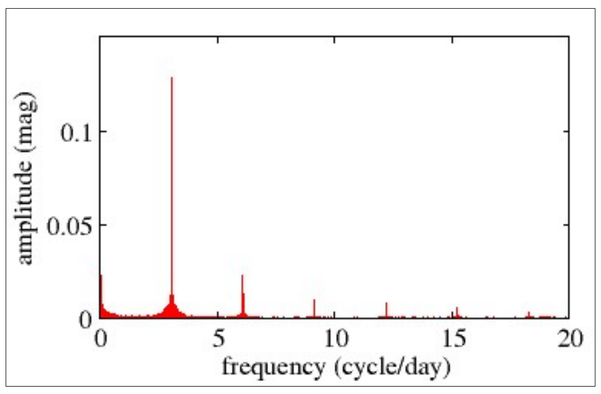

Figure 2. *Fourier spectrum based on the 2.5 years of TESS data. There is not any other significant peak beyond the main pulsational frequency and its harmonics.*

Light curve analysis

We collected new photometric data to study the period change. Beyond the 12 years of MACHO data (Hart et al. 1996), OGLE (Udalski et al. 1997) observed it in phases III and IV, adding another 15 years of data. TESS (Ricker et al. 2015) has been also observing BE Dor in several sectors. We extracted the data using differential image analysis, the phase diagrams of data in all available sectors are shown in Fig. 1. At the present time, 2.5 years of TESS data is available to us. We studied the frequency content of the light curve with standard Fourier transform (FT) method by using Period04 (Lenz & Breger 2005). We detected the main pulsation frequency at f=3.0481907c/d and its harmonics but none of the residual spectra contained any other significant peak (Fig. 2). The Fourier analysis of the TESS data unambigously confirmed the monoperiodic nature of BE Dor.

O—C diagram

In order to study the period change (and therefore the possible binary nature of this object), we calculated the O—C diagram (Fig. 3) using the collected photometric data. Although the O—C diagram unambigously show continuous period variation, it is not purely cyclic anymore as it was detected in Derekas et al. (2004).

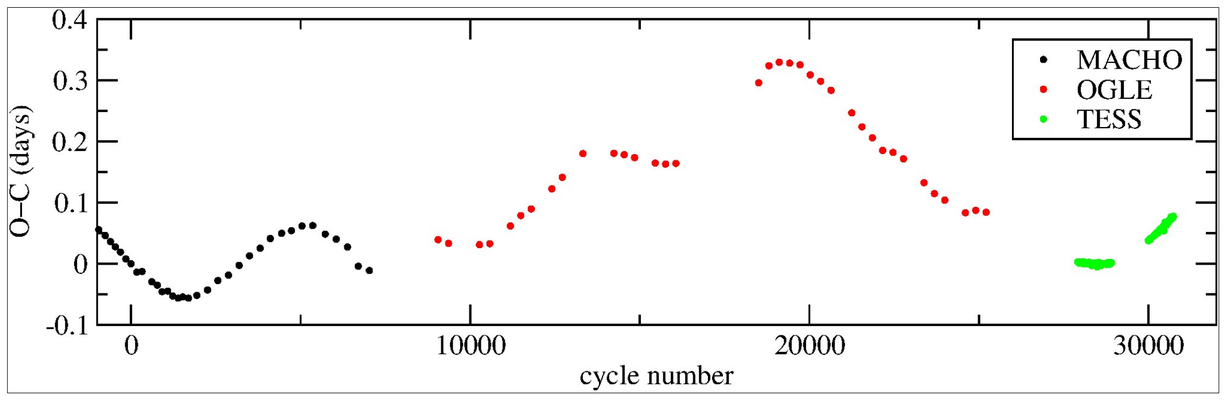

Figure 3. *The O–C diagram of BE Dor based on MACHO, OGLE and TESS photometry.*

Spectroscopy

We also obtained medium resolution spectra in 3 different years in order to check if BE Dor resided in a binary system. We took spectra in 2004 and 2005 with the 2.3m telescope located at Siding Spring Observatory, Australia. We obtained additional data in 2017 with the MIKE spectrograph of the Clay telescope at Las Campanas Observatory, Chile.

We determined the radial velocities (RV) applying the cross-correlation method using a well-matching theoretical template spectrum from the extensive spectral library of Munari et al. (2005). The resulted RV curves are shown in Fig. 4. We could not detect any vertical shift in the radial velocity curves (expected from a hypothetic binary motion), so that all data point toward the single nature of BE Dor. Whatever causes the enormous period/phase modulation, it remains a mystery. Detailed study will be published soon.

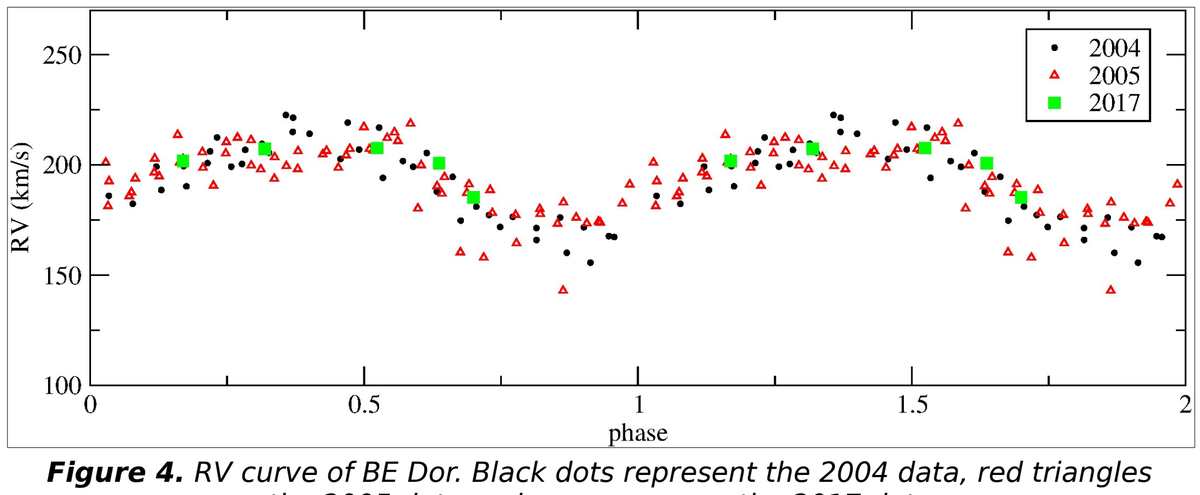

Figure 4. *RV curve of BE Dor. Black dots represent the 2004 data, red triangles the 2005 data and green squares the 2017 data.*

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