

Amplitude variations of the CoRoT Be star 102719279

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The Be star 102719279 is an interesting target observed with CoRoT during two runs, giving us the possibility to study the stability of the detected frequencies and to search for any correlation with outbursts, as it was recently found in the Be star HD 49330 (Huat et al. 2009). The light curve of the star 102719279 shows fadings, multiperiodicity, stable and transient frequencies, etc. The short-term variations of the light curve are probably produced by non-radial pulsations together with some material that is ejected from the star, which produces the transient frequency. It is should be noted that the two main frequencies are synchronized and have the maximum amplitude just before the outburst.

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1 Introduction

Be stars are main-sequence or slightly evolved B stars surrounded by an equatorially condensed disk fed by discrete mass-loss events, also called outbursts. Although Be stars are rapid rotators, their rotational velocity does not reach the break-up velocity (they rotate in average at about 90%, Frémat et al. 2005) and the disk formation mechanisms are still unknown (Porter & Rivinius 2003). Be stars are also known to show short-term variations caused by non-radial pulsations (eg. Diago et al. 2009, Neiner et al. 2009) and/or rotational modulation (eg. Balona 1990; Balona 2009). Non-radial pulsations could provide the additional amount of angular momentum to eject the material to form the disk (Osaki 1986). Based on an exhaustive spectroscopic campaign, Rivinius et al. (1998) showed that multimode pulsation was playing a triggering role in the mass transfer in the Be star μ Cen. In the star 102719279, thanks to the high-precision and long-duration photometric data of CoRoT, Gutiérrez-Soto et al (2008) found a clear correlation between the amplitude variations and the outbursts. More recently, Huat et al. (2009) showed that the outburst occurred just after the moment the two main frequencies had the maximum amplitude in the Be star HD 49330.

The objective of this paper is to give more clues to understand the link between non-radial pulsations and the outbursts in Be stars by performing a detailed analysis of the amplitude variations of the light curve of the star 102719279.

2 Observations

The star 102719279 was observed in the exoplanetary field of CoRoT from 2007 February 3 to April 1 in the initial run

(IR, 57 days) and from 2007 October 23 to 2008 Mars 3 in the first long run towards the Galactic anticenter direction (LRA1, 131 days).

A low-resolution spectra (3250–8800 Å, $R \sim 400$) was obtained in 2008, Mars 11 with CAFOS at the 2.2m telescope in Calar Alto. In addition, in 2009, January 13 and 15, two medium-resolution spectra in the blue and red bands were acquired with VLT-FLAMES in medusa mode ($R \sim 7000$, ESO programme 082.D-0839(A), PI: Coralie Neiner). See Semaan et al. (2010) in these proceedings for a detailed explanation of the observations and reduction.

3 The star 102719279

The star 102719279 is an early B2.5e star with shell features visible in the Balmer and metal lines. The $H\alpha$ profile exhibits a double asymmetrical emission line with a deep and sharp absorption at the center. $H\alpha$ was observed in emission ($I/I_c = 4.5$) in both spectra, in 2008 Mars 11 and in 2009 January 13–15.

For the determination of the stellar parameters, we used the GIRFIT program (Frémat et al. 2005). This method adjusts by least-squares fitting the observations with synthetic spectra interpolated in a grid of stellar fluxes computed with SYNSPEC (Hubeny & Lanz 1995) and from model atmospheres calculated with TLUSTY (Hubeny & Lanz 1995) and ATLAS9 (Kurucz, 1993). The best fit was found with the following *apparent* parameters: a T_{eff} of 20000 ± 1500 K, $\log g$ of 3.5 ± 0.2 dex and a $V \sin i$ of 270 ± 20 km s⁻¹. We only used the photospheric lines without shell contamination. The parameters were not corrected from veiling caused by the emission nor from the effects of the stellar flattening and gravitational darkening caused by the rapid rotation (Frémat et al. 2005).

From the fundamental parameters we see that the star is located inside both β Cep and SPB instability strips. In

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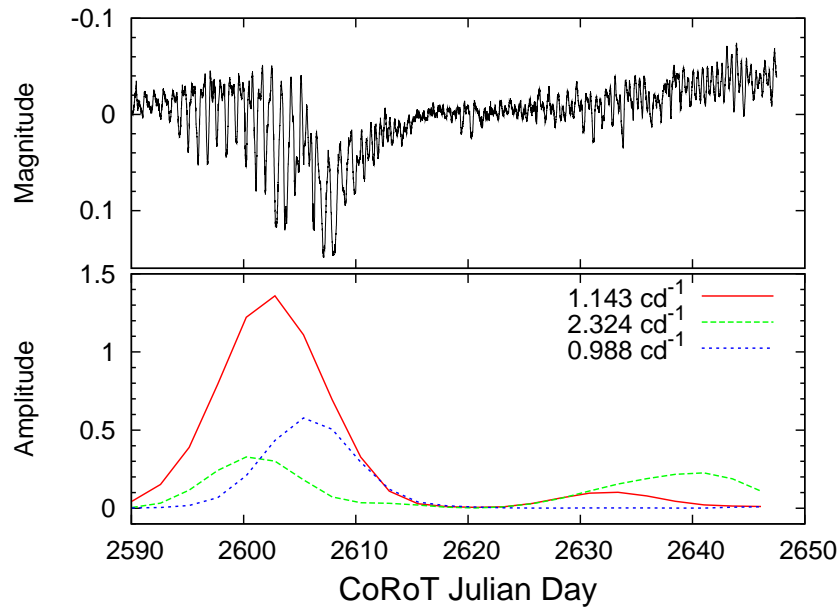


Fig. 1 In upper panel, light curve of the IR dataset and, in bottom panel, amplitude as a function of time (in arbitrary units) of the frequencies with largest amplitudes.

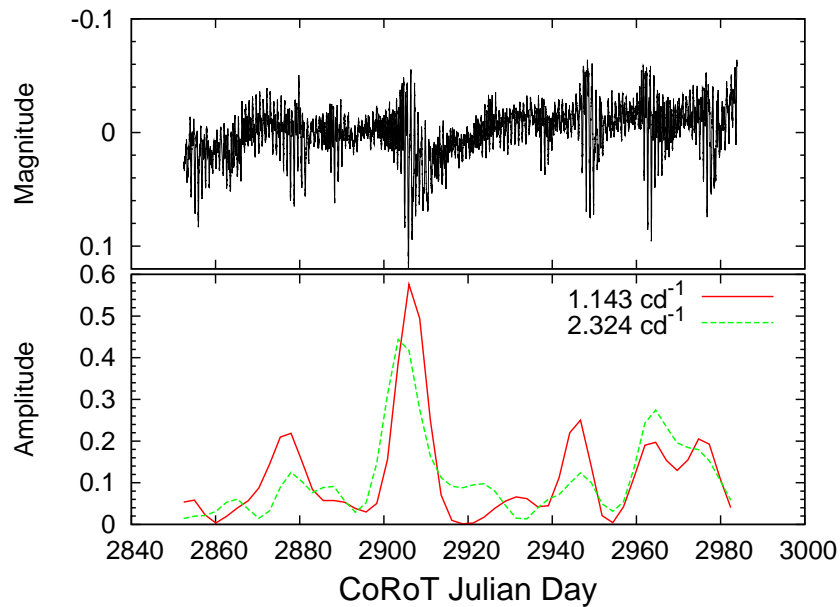


Fig. 2 Idem as Fig. 1, but for the LRA1 dataset.

addition, we derived a rotational frequency of $1.19 \pm 0.3 \text{ c d}^{-1}$ from the radius calibration of Balona (1995). The star is seen equator-on ($i \sim 90 \text{ deg}$).

4 Analysis of the CoRoT light curve

The light curves of the IR and the LRA1 (upper panel of Figs. 1 and 2 respectively) clearly show short-term variability. We also observe some sudden changes with amplitudes of several hundredths of magnitude, also called outbursts. In this star, due to the high inclination of the line of sight, the ejected material produces an obscuration of part of the photosphere and thus we see a fading.

In order to study the short-term variations, we perform a standard Fourier analysis of both light curves. Multiple significant frequencies are detected in the periodograms in the $0.8\text{--}1.5$ and $2\text{--}2.6 \text{ c d}^{-1}$ frequency ranges. In Figs. 3 and 4 we display the periodogram of both datasets (IR in solid red and LRA1 in blue dashed line) between $0.8\text{--}1.5 \text{ c d}^{-1}$ and $2\text{--}2.6 \text{ c d}^{-1}$ respectively. We also find more significant peaks in other frequency ranges, but they are probably combinations or harmonic of the frequencies with the largest amplitudes.

From a first look at the periodograms we see that the amplitudes of the detected frequencies change substantially with time. Several frequencies seem to appear and disappear from the IR to the LRA1. However, other frequencies are detected in both runs, as for example 2.324 c d^{-1} , although with different amplitude. We have summarised in Table 1 the 5 frequencies with the largest amplitude detected separately in each dataset. Note that, in the LRA1, for which we have better resolution, there are no frequencies that are exactly the double of another. It is also important to highlight that the sinusoidal fittings with these 5 frequencies are not accurate enough to reproduce the light curves, and many more frequencies are needed, specially close to the times of the fadings. In addition, a frequency at 0.988 c d^{-1} is only detected in the IR.

In order to determine the variations of the amplitudes of the main frequencies as a function of time, we have employed a method based on a wavelet analysis, using the well known Morlet wavelet. This method was described and applied to solar seismic data in Baudin et al. (1994) and to a CoRoT light curve of the Be star HD49330 in Huat et al. (2009). The frequency resolution (the full width at half maximum of the wavelet in the Fourier domain) used in the present case is 1 Hz, corresponding to a time resolution of 2.5 days.

We display in the lower panel of Figs. 1 and 2 the amplitude (in arbitrary units) of the frequencies 1.143 , 2.324 and 0.988 c d^{-1} (the latter only detected in the IR). The amplitudes of the main frequencies (1.143 and 2.324 c d^{-1}) seem to be synchronized reaching the maximum amplitude very close to the time when the outbursts occur. This is seen in the fading of the IR and in most of the largest fadings of the LRA1. The amplitudes are maximum just before the sudden

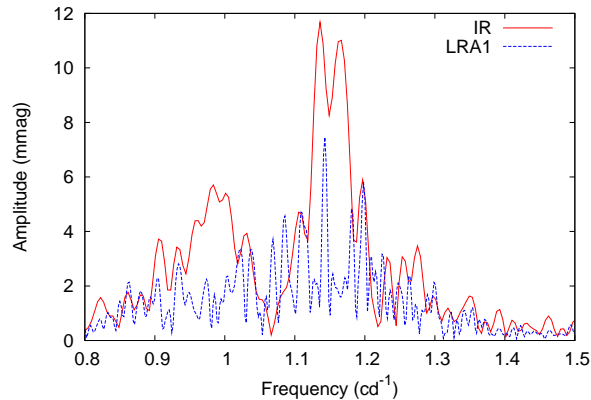


Fig. 3 Periodograms of the IR (red) and the LRA1 (blue) light curves in the $0.8\text{--}1.5 \text{ c d}^{-1}$ frequency range.

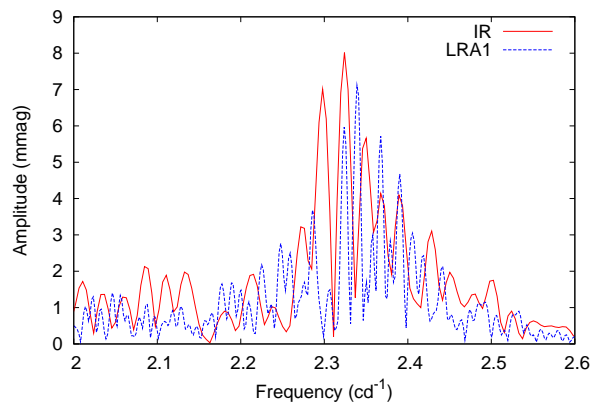


Fig. 4 Periodograms of the IR (red) and the LRA1 (blue) light curves in the $2\text{--}2.6 \text{ c d}^{-1}$ frequency range.

decrease of the flux, as Huat et al. (2009) found for the Be star HD 49330.

In the lower panel of Fig. 1 we see that the frequency 0.98 c d^{-1} is only detected during the first 20 days of the IR, reaching the maximum amplitude when the flux of the star starts to decrease. In addition, it occurs just after the time of the maximum amplitude of the main frequencies (1.143 and 2.324 c d^{-1}). Stefl et al. (1998) detected similar transient variations in other Be stars and linked them to material in the inner or outer part of the circumstellar disk, which appeared at times of outbursts. The transient period is normally 10% of the genuine ones, which matches very well with our values.

5 Conclusions

The light curve of the Be star 102719279 shows short-term multiperiodic variability. In addition, the amplitudes of the frequencies change substantially between and during the two studied datasets. The variability could be interpreted as non-radial pulsations and the changes in the amplitudes as the beating of the modes. We would need pulsating models that

Table 1 Table with the 5 largest-amplitude frequencies for the IR and the LRA1 datasets.

IR			LRA1		
Frequency ($c d^{-1}$)	Amplitude (μHz)	Amplitude (mmag)	Frequency ($c d^{-1}$)	Amplitude (μHz)	Amplitude (mmag)
1.133	13.113	11.4	1.143	13.227	7.3
1.168	13.519	11.6	2.339	27.074	6.9
1.156	13.380	9.4	2.324	26.898	5.9
2.324	26.898	8.0	1.198	13.866	5.5
0.988	11.435	5.8	2.368	27.407	5.3

take into account the rapid rotation to confirm this interpretation.

In addition, the light curve of this star shows fadings or ejections of material that hides part of the photosphere. In Gutiérrez-Soto et al. (2008) we performed a preliminary analysis of the first dataset (IR) and we found a correlation between the amplitude of the main frequencies and the fadings. Here we have studied in more detailed the amplitude variations of the same dataset (IR) and of a new one (LRA1), which contains more fadings. We have found in both datasets that the ejection of matter occurs just after the time when the amplitudes of the main frequencies are synchronised and are at the maximum value, as seen in Huat et al. (2009) for the Be star HD 49330.

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