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# PULSATION MODES DETECTED BY COROT IN THE HOT BE STAR HD 51452

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**Abstract.** HD 51452 is a hot Be star observed by CoRoT and simultaneous spectroscopy. This star shows pulsation p modes of $\beta$ Cephei type as expected for this spectral type, as well as $g$ modes with lower frequencies, which are not expected in such stars. We investigate whether this is due to the rotational flattening of the star, allowing for cooler regions at the equator from which SPB-type $g$-modes excited by the $\kappa$ mechanism could arise, but conclude that the detected modes are rather stochastic $g$-modes.

Keywords: stars: emission-line, Be – stars: individual: HD 51452 – stars: oscillations – Stars: rotation

## 1 Introduction

Be stars are known to pulsate. As of today, the driving mechanism of pulsations in Be stars is thought to be the $\kappa$ mechanism, i.e. an effect of the opacity of iron-peak elements in the envelope of the star (Dziembowski & Pamiatnykh 1993; Dziembowski et al. 1993). This mechanism only occurs when the opacity bump coincides with the adiabatic and non-adiabatic transition zone. Pressure ($p$) and gravity ($g$) modes can then be auto-excited, depending on the depth at which the iron opacity bump is situated in the envelope, i.e. depending on the temperature of the star. In the Milky Way, $p$-modes are observed in stars down to the B3 spectral type, while $g$-modes are observed from the B2 spectral type downwards.

## 2 Observations of HD 51452

HD 51452 is a hot Be star observed with the CoRoT satellite during 114.4 consecutive days. Simultaneously, ground-based observations have been obtained during about 1 month in spectroscopy with HARPS (ESO) and SOPHIE (OHP). Additional spectra from the BeSS database have also been collected, more scarcely but over the whole CoRoT run.

HD 51452 is a B0IVe star as shown by Frémat et al. (2006). For such a hot star, the $\kappa$ mechanism can create $p$-modes of pulsations, but cannot excite $g$-modes. Neverthesless, the pulsation analysis of the CoRoT data of HD 51452 shows that several frequencies below 2 c d$^{-1}$, i.e. in the frequency domain usually attributed to $g$-modes, are detected (see Fig. 1) in addition to frequencies of fainter amplitude in the $p$-mode domain. HD 51452 thus appears as a hybrid pulsator despite its hot spectral type, which is incompatible with the limits of the instability strips determined from theory or observed so far in the Milky Way (e.g. Miglio et al. 2007).

## 3 Discussion

### 3.1 Flattening of the star

Since HD 51452 rotates close to its critical velocity, the star is very flattened and its temperature is very different at the pole and at the equator. One possible explanation is therefore that the temperature in the equatorial region is low enough to allow the excitation of $g$-modes by the $\kappa$ mechanism, while $p$-modes would be excited in the rest of the star. The inclination angle at which we observe the star is around ∼45 degrees, and the observer thus indeed sees both the pole and equator of the star. Accordingly, the spectra reflects the average temperature

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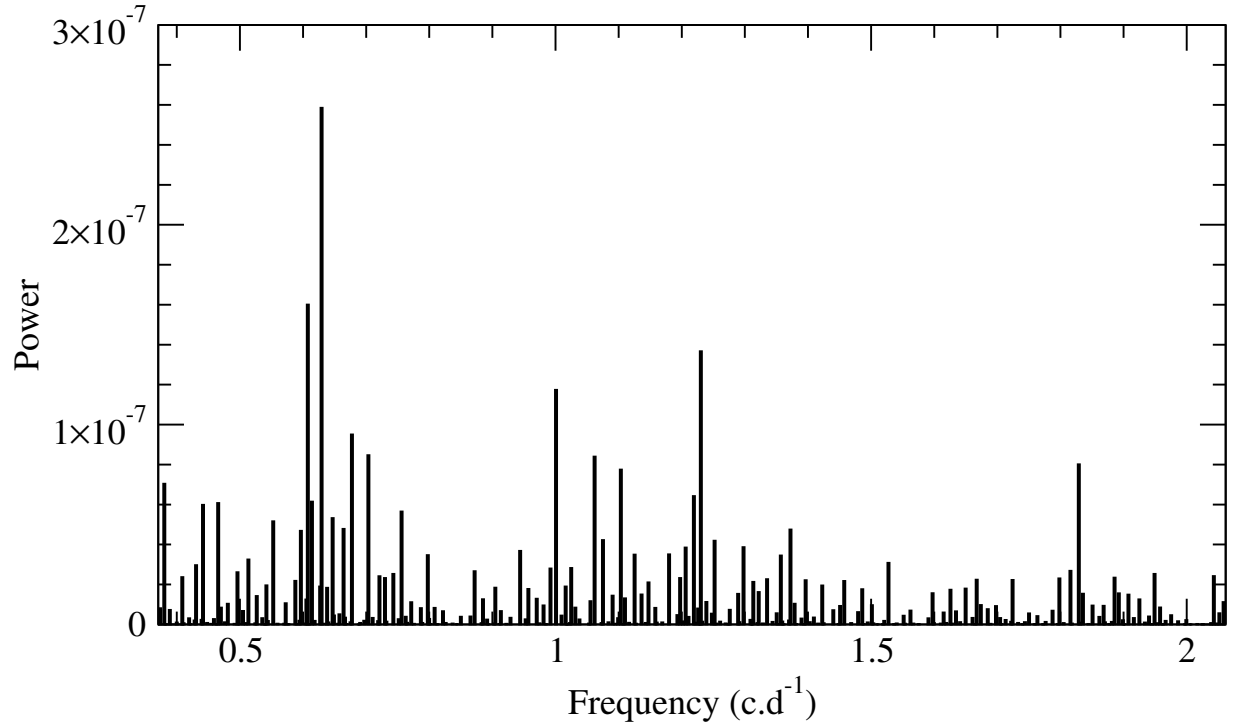


**Fig. 1.** Power spectrum of the CoRoT data, showing the frequency region $f$=0.5 to 2 c d$^{-1}$ where $g$-modes are detected.

at the stellar surface. A difference of more than 10000 K would be required between the temperature at the poles and at the equator for the latter to be cool enough to host $g$-modes. Such a steep profile of temperature is unlikely even with a very strong flattening.

### *3.2 Stochastic modes*

The low frequencies detected in the CoRoT data of HD 51452 should thus be attributed to another excitation mechanism than the $\kappa$ mechanism. Stochastic low radial order $g$ modes can be excited in the convective core of Be stars while asymptotic $g$ modes can be excited by the iron ionization opacity peak in the sub-surface convection zones (Samadi et al. (2010), see also Cantiello et al. (2011)). Moreover, the convective sub-surface layer is thicker at the equator than at the poles in Be stars because of their rapid rotation and flattening. Stochastic $g$-modes thus appear has a realistic explanation for the presence of low frequencies in this star. However, the impact of rapid rotation on the excitation of stochastic $g$ modes has only been studied for lower mass stars so far (Belkacem et al. 2009). Note that stochastic $g$-waves are also put forward as an explanation (Neiner et al. 2011) for the CoRoT observations of the outbursting Be star HD 49330 (Huat et al. 2009; Floquet et al. 2009).

## 4 Conclusions

HD 51452 is a hot Be star hosting $g$-modes. Considering the temperature of the star, these modes cannot be driven by the $\kappa$ mechanism. However, stochastic $g$ modes are predicted by recent theoretical work in early-type stars, and the rapid rotation of HD 51452 may facilitate the presence of a sub-surface convective zone. Thus HD 51452 is probably the first Be star for which stochastic $g$ modes are clearly detected.

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