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KIC 6761539, a fast rotating γ Dor – δ Sct hybrid star

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Abstract. KIC 6761539 is one of many fast rotating γ Doradus – δ Scuti hybrid pulsators. A search for possible regularities in the frequency spectrum is performed and a first stellar model is presented.

Keywords. stars: individual KIC 6761539, stars: oscillations, stars: variables: δ Scuti

1. Introduction

The candidate γ Doradus - δ Scuti hybrid star KIC 6761539 (Uytterhoeven *et al.* 2011) is a rather fast rotator, with a value of 120 km s^{-1} for the projected rotational velocity ($v \sin i$). In this case study, we perform a search for all possible regularities in the frequency spectrum such as harmonics, combination frequencies and frequency spacings. Finally, we present a first preliminary model for the star.

For the analysis presented here, *Kepler* time series from Q0 to Q10 (May 2009 to September 2011) were used. The frequency extraction was carried out with the software tool 'Pysca' (Herzberg & Glogowski, these proceedings), which works via consecutive prewhitening of the time series. We decided to limit the analysis to frequencies with a signal-to-noise ratio higher than 9.5, yielding a set of 171 frequencies.

2. Harmonics and combination frequencies

Within our set of 171 frequencies, a search for harmonics was performed up to 5th order. This yields a total of three candidate harmonic frequencies:

$$\begin{aligned} F105 &= 5 \cdot F6 \pm 3 \cdot 10^{-5}\ \mathrm{d}^{-1} \\ F44 &= 5 \cdot F34 \pm 4 \cdot 10^{-4}\ \mathrm{d}^{-1} \\ F83 &= 2 \cdot F55 \pm 1 \cdot 10^{-3}\ \mathrm{d}^{-1} \end{aligned}$$

As the harmonics are either of high order ($n = 5$), or involve not the highest amplitude frequencies (F55), we suspect an agreement by chance in all three cases.

For the identification of combination frequencies, we included the fifteen highest amplitude frequencies as parent frequencies in our search. Eight candidate combination frequencies of second order were found:

$$F38 = F13 - F6 \pm 2 \cdot 10^{-4}\ \mathrm{d}^{-1} \qquad F128 = F8 - F5 \pm 3 \cdot 10^{-5}\ \mathrm{d}^{-1}$$
$$F49 = F14 - F5 \pm 1 \cdot 10^{-4}\ \mathrm{d}^{-1} \qquad F133 = F12 + F13 \pm 9 \cdot 10^{-4}\ \mathrm{d}^{-1}$$
$$F100 = F11 + F15 \pm 2 \cdot 10^{-3}\ \mathrm{d}^{-1} \qquad F137 = F10 - F12 \pm 3 \cdot 10^{-4}\ \mathrm{d}^{-1}$$
$$F112 = F14 - F8 \pm 6 \cdot 10^{-5}\ \mathrm{d}^{-1} \qquad F154 = F7 + F14 \pm 1 \cdot 10^{-3}\ \mathrm{d}^{-1}$$

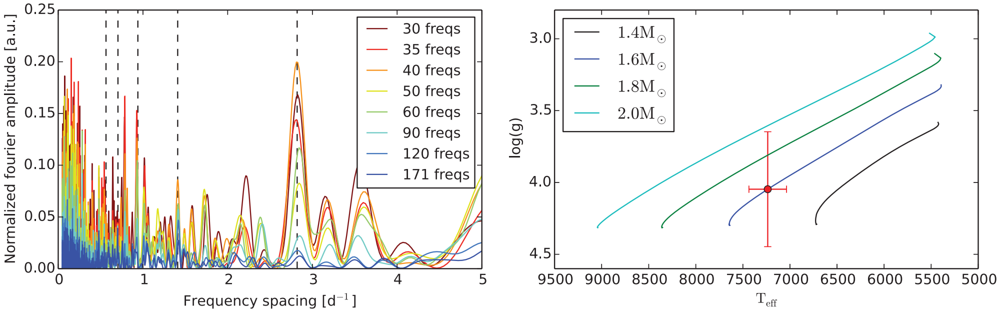

Figure 1. *Left*: DFT for different frequency sets. *Right*: Best fitting model for KIC 6761539. Four evolutionary tracks for different masses are shown as comparison.

It becomes evident that none of the parent frequencies is involved in a systematic way in these detections. Many higher order combinations were also detected, but since no systematic pattern appears, their physical significance remains unclear.

3. Preferred frequency spacing

We searched for a regular spacing in the frequencies by applying the discrete Fourier transform (DFT) to the frequency set, as presented in García-Hernández *et al.* (2013). We calculated the DFT for several groups of frequencies from the original set, starting with the 30 highest amplitude modes and slowly adding more and more lower amplitude modes (see Fig. 1, left panel). A preferred spacing of about 2.82 d^{-1} seems to be present, which is most pronounced between the first 40 frequencies. Submultiples up to 3rd order are visible.

4. First stellar model

A preliminary model for KIC 6761539 was calculated with the stellar evolution code MESA (Paxton *et al.* 2011). The best fitting model (see Fig. 1, right panel) was found with a least-squares minimization of the surface gravity $\log g$ and effective temperature $T_{\rm eff}$, the values of which are taken from the *Kepler* Input Catalog (Brown *et al.* 2011). The model has a mass of 1.62 $M_\odot$ and an age of about 1.42 Gyr, corresponding to a hydrogen fraction of 0.48 in the core. The metallicity and chemical composition are taken to be solar, and the initial value of the rotation rate on the ZAMS is chosen equal to 30% of the critical rotation rate.

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