Multiperiodicity of HR 6534

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ABSTRACT

Detection of the variability of the star HR 6534 is presented. As a multiperiodic δ Scuti star, HR 6534 is an interesting potential target for the COROT observing programme despite its high rotational velocity.

1. Observations

HR 6534 was discovered to be variable when the star was used as a comparison star for ζ Ser. ζ Ser was found by C. Catala to be a spectroscopic variable in the input catalogue for COROT but turned out to be photometrically constant, at the level of 2 mmag, but HR 6534 showed the photometric variations plotted in Fig. 1.

Observations were made with the simultaneous 4-channel Strömgren photometer attached to the 0.9m telescope in Sierra Nevada Observatory. In order to gain a higher S/N ratio the magnitudes in Fig. 1 come from an addition of the count rates for the filters v and b of the Strömgren system.

2. Preliminary frequency analysis

$\nu(\mu$Hz)	Amp (mag)	phase (rad)	ν_i/ν_0	ν_i/ν_1
158.92	0.0022 ± 0.0003	3.40 ± 0.16	1	-
207.45	0.0039 ± 0.0004	4.57 ± 0.09	0.77	1
237.38	0.0018 ± 0.0004	1.47 ± 0.19	0.67	0.87
291.95	0.0022 ± 0.0004	4.84 ± 0.16	0.56	0.71
353.76	0.0029 ± 0.0003	0.25 ± 0.12	0.45	0.59

Table 1: Fitted frequencies of HR 6534.

A least square fit following the procedure described in detail in Vanicek (1971) gave the results indicated in Tab. 1. With the amplitudes approximately determined by this analysis and listed in Tab. 1, a schematic frequency spectrum is pictured in Fig. 3.

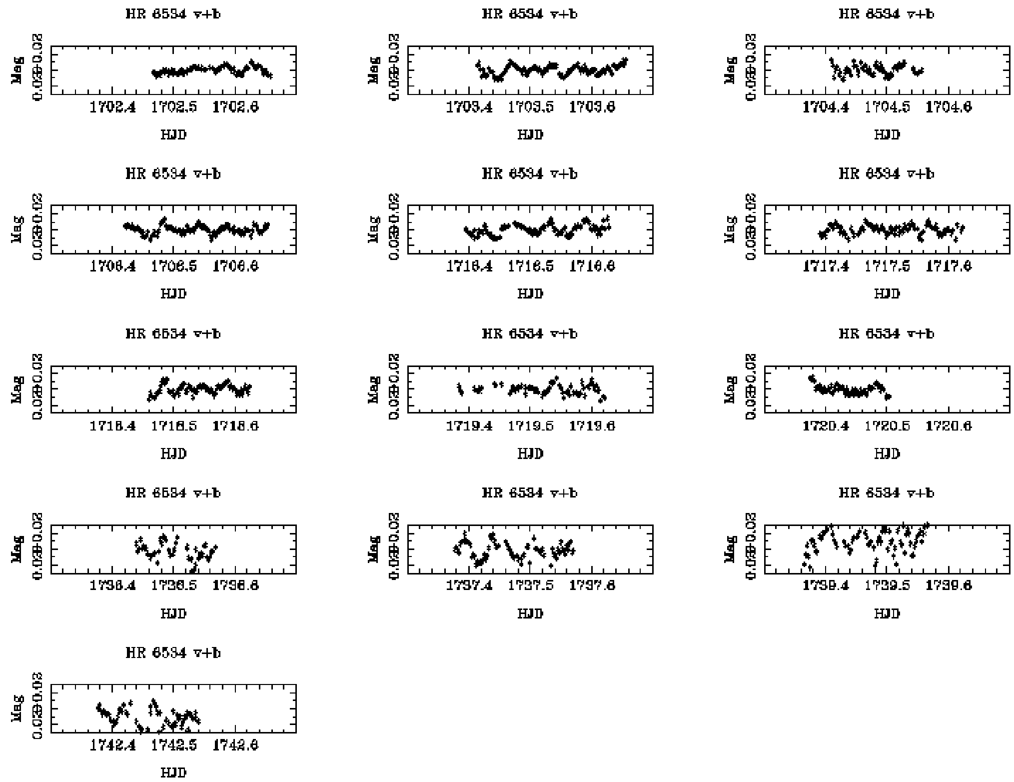

Fig. 1.— v+b magnitudes vs. HJD

3. Preliminary theoretical interpretation

A first look at the period ratios of Tab. 1 could indicate that HR 6534 is a pure radial oscillator. In fact, they almost match the canonical values for a nonrotating star. The problem arises when a rapid rotation is taken into account: the star has a $v \sin i$ of 255 km/s. Fast rotation introduces changes in the period ratios even for radial modes and, which is much important, gives rise to shifting of the rest frequencies as we will show in the next section.

This, of course, does not ensure that the modes are radial modes, nonradial modes exist in the same frequency range and can be excited as well. They would yield similar period ratios.

3.1. Location in the HR diagram

Strömgren photometric indices for this star are: $(b-y)_0 = 0.108, m_0 = 0.177, c_0 = 0.912$ and $\beta = 2.827$. Using the photometric calibration of Balona (1994) we found a $\log\ L/L_{\odot} \sim 0.99$ and a

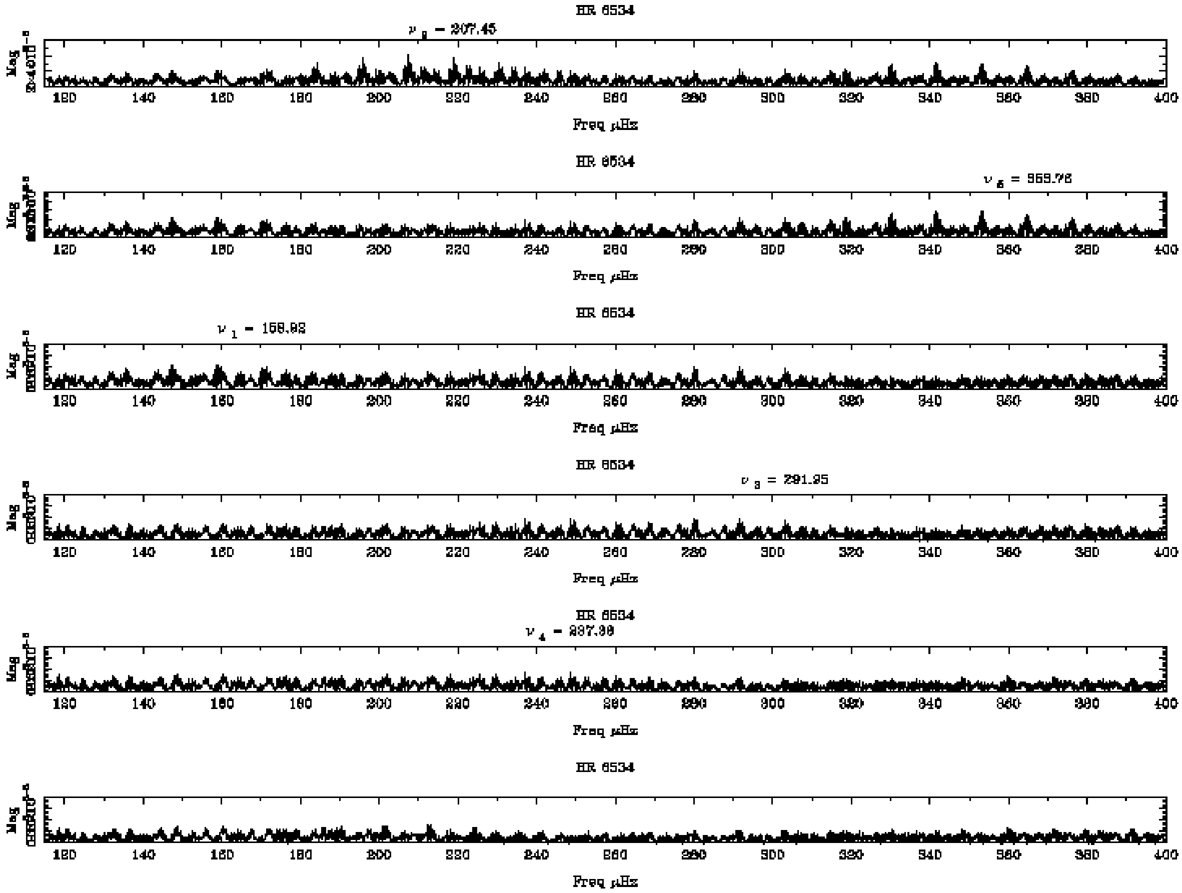

Fig. 2.— Power spectra for the data shown in Fig. 1 (top panel). Prewhitening proceeds from top to bottom.

$\log\ T_{\rm eff} \sim 3.896$ with the incertitudes indicated by the error box of Fig. 4.

This yields to a very young star with a mass around $1.75\ M_\odot$. Radial oscillation frequencies computed for $1.75\ M_\odot$ models with $\log T_{\rm eff} = 3.90$ and $\log T_{\rm eff} = 3.89$ are indicated in Tab. 2.

3.2. A fast rotator

Fast rotation causes a shift in the location of the star in the HR diagram i. e., affects the determination of its mass and age (Perez Hernandez et al. 1999). A fast rotation modifies period ratios and the effect can be seen in Tab. 2. Fast rotation is also an additional source of confusion when nonradial modes are excited. Effects of rotation upon the equilibrium model and its oscillation frequencies have been computed according to a perturbation theory including effects of degenerate coupling (in particular between $l = 0$ and $l = 2$;

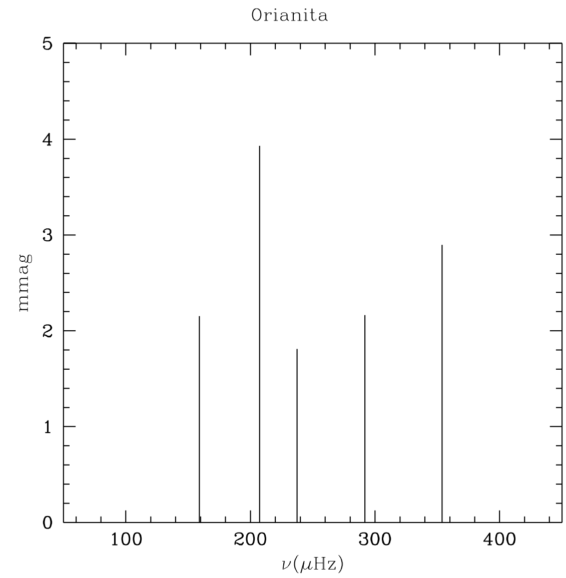

Fig. 3.— "Cleaned" frequency spectrum of HR 6534.

$m = 0$ modes) (Soufi et al. 1998 and Goupil et al. 2000). The effect becomes dramatic when 250 km/s is reached, in fact the period ratios can even mimic radial canonical ratios, but shifted by one radial order (!), as can be seen in Tab. 2. However caution must be taken since at that very large velocity the perturbation method here used can fail.

4. A possible target for COROT

The observations were made from a single observatory and the final frequency solution suffers from the aliasing confusion at one cycle/day. In any case this star deserves more observations, in multisite campaigns, since there are not many multiperiodic δ Scuti bright enough in the sky zones where COROT is expected to be pointed.

Sky position and magnitude are well into the range of potential δ Scuti targets for COROT:

V (mag)	α(2000.0)	δ(2000.0)
5.6	17 33 29.84	-05 44 41.3

HR 6543 could be a good target to investigate rapid young rotators.

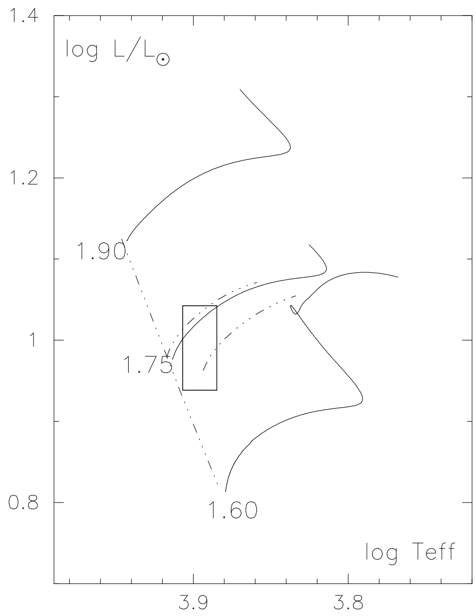

Fig. 4.— Location of HR 6534 in a theoretical HR diagram. Solid lines correspond to evolutionary tracks for $1.90, 1.75$ and $1.60\,M_{\odot}$. Spherically symmetric distorsion due to the centrifugal force is taken into account with a rotational velocity of $v = 100$ km/s. The dash-dotted line represents the ZAMS. Dotted lines represent $1.75\,M_{\odot}$ evolutionary tracks with $v = 0$ (upper one) and $v = 250$ km/s (lower one). Error box comes from photometry.

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Vanicek P. 1971, ApSS 12 10

v (km/s)	log $T_{\rm eff}$	ν_0 (μHz)	P_1/P_0	P_2/P_0	P_3/P_0	P_4/P_0	P_5/P_0
0	3.90	207.2	0.7718	0.6305	0.5328	0.4581	0.3990
$100^{\rm b}$	3.90	210.6	0.7775	0.6334	0.5362	0.4616	0.3980
0	3.89	188.2	0.7717	0.6279	0.5296	0.4558	0.3980
$100^{\rm b}$	3.89	191.2	0.7825	0.6275	0.5343	0.4604	0.3970
$250^{\rm a}$	3.89	203.4	0.7873	0.6432	0.5455	0.4729	0.4158
$250^{\rm b}$	3.89	221.2	0.8838	0.7364	0.6351	0.5529	0.4880

Table 2: Frequency of the fundamental radial mode and period ratios for radial modes of a $1.75\ M_\odot$ model with no rotation ($v = 0$) and with a rotational velocity of $v = 100$ km/s and $v = 255$ km/s.

[a] no degenerate coupling included

[b] degenerate coupling included