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The oscillation modes of the β Cephei star in HD 92024 in the open cluster NGC 3293

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Abstract. The primary star of the binary HD 92024 is a prominent β Cephei variable; three oscillation frequencies are known, it is an eclipsing binary component and has cluster membership (NGC 3293). Towards asteroseismic inferences of the star's three known oscillation frequencies, we use photometry and spectroscopy to find that $f_1 = 5.6400$ c d^{-1}, $f_2 = 7.1624$ c d^{-1} and $f_3 = 6.6584$ c d^{-1} are modes of degree $l = 2, 4$ and 2 respectively, all with $m \neq 0$. We also find that by combining pulsational information from several spectral lines, we suppress the noise and improve the mode-identification process. In conclusion, HD 92024 is a key object to be subjected to a seismic analysis.

Key words. Stars: HD 92024 – eclipsing – pulsating – beta Cephei stars

1. HD 92024

Freyhammer et al. (2005) improved the values of 3 known photometric frequencies of HD 92024's β Cephei primary to: $f_1 = 5.6400$ c d^{-1}, $f_2 = 7.1624$ c d^{-1} and $f_3 = 6.6584$ c d^{-1}. f_2 and f_3 were also detected in the star's profound spectroscopic line-profile variations and an orbital analysis was carried out. The photometric and spectroscopic variability, together with the knowledge of the star's orientation and dimensions, motivates an asteroseismic analysis. For a description of the observations and data reduction we refer to Hensberge et al. (2004). In what follows, a combination of methodologies is used to identify the modes of f_1, f_2 and f_3.

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2. Mode identification

We studied the power of the temporal intensity variations for all spectrum bins across four relatively unblended spectral lines — Si III λ4552, Si III λ4567, He I λ5875 and He I λ6678 — totalling 350 power spectra. The mean power spectrum is by far dominated by f_2 as opposed to photometry, but all three frequencies are significant on a 4σ level. Fig. 1 shows the corresponding amplitude and phase variations for f_1, f_2 and f_3 across the four lines. Excellent agreement is seen for all lines.

Eq. 9 by Telting & Schrijvers (1997) suggests, from the phase differences across the

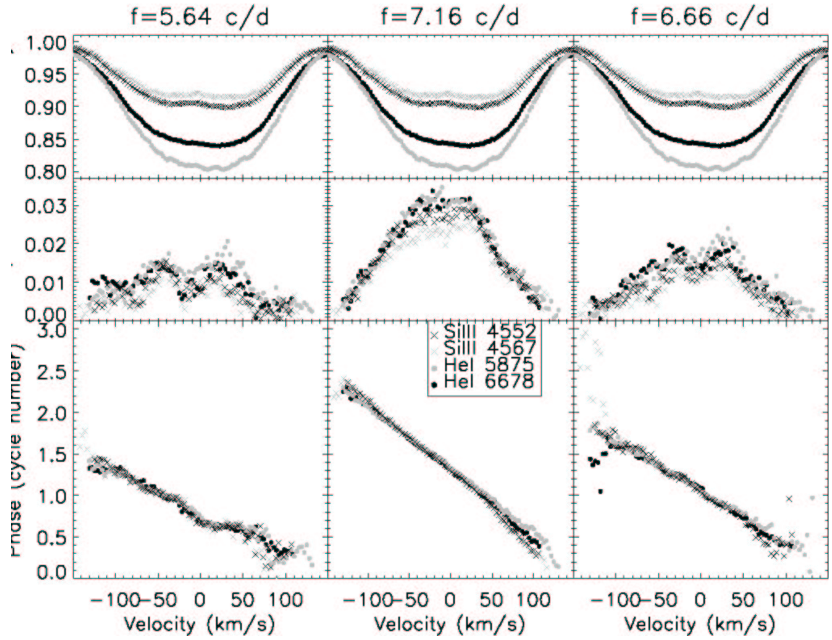

Fig. 1. Amplitude (middle row of panels) and phase (lower panels) diagrams for the time-series spectroscopy for f_1, f_2 and f_3 (from left to right). Four line profiles were used (mean profiles in the top panels).

lines, degrees l = 2–3 (2.5±1.0) for f_1 and f_3, and l = 4–5 (4.5±1.0) for f_2. Moreover, the high amplitudes observed near the centre of the amplitude diagrams in Fig. 1 exclude $m = 0$.

The comparison of the observed *uvby* amplitudes with those calculated for modes of a grid of stellar models, with parameters based on the findings of Freyhammer et al. (2005), indicates that f_1 and f_3 are $l = 2$ modes while $l \geq 4$ and even for f_2 (cf. Dupret et al. 2003). However, because all frequencies are detected in the photometry the degrees l cannot be very high; therefore $l = 4$ for f_2. Finally, we applied the moment method (Briquet & Aerts 2003), which is ill suited for high-degree modes. Phased with f_1, f_2 and f_3, the dominant moment variation is seen for $<v^2>$, which is partly a consequence of the star's rotation. These variations are sinusoidal, confirming $m \neq 0$. At present, moments do not really aid the mode identification but we plan to calculate theoretical amplitude and phase variations of the most promising moment solutions with $l = 2, 4, 2$ for f_1, f_2 and f_3 respectively, and to compare them with the observed ones (Fig. 1) to put further constraints on m.

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