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A Period Analysis of the Optical Line Variability of β Cephei [1]

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1. Introduction

Recently Aerts et al. (1994, Paper I) discovered multi-periodicity in the variations of optical lines of β Cephei. They identified the frequency of the radial pulsation ($f_1 = 5.25$ cycles/day), and additionally found 2 frequencies ($f_2 = 5.38$ c/d, $f_3 = 4.92$ c/d) close to the main frequency. The amplitude of these variations was found to be much smaller than that of the radial pulsation. Aerts et al. (1994) attributed these small variations at the newly found frequencies to non-radial pulsation modes of the star, but labelled the mode-identifications as uncertain.

As a follow up on this work, we investigated the whole frequency range that can be analysed with the data set described in Paper I. For four absorption lines (Si III λ 4552, 4567, 4574 and O II λ 4591) we examined variations in EW and the velocity moments of the absorption lines (yielding the velocity shift, line width and skewness). We also investigated the variations of the normalised intensity for each individual wavelength bin of the spectra.

2. Results

We find, apart from the already known frequencies, two other frequencies ($f_4 = 5.08$ c/d, $f_5 = 5.42$ c/d) around the main frequency, which have variations exceeding the noise level. These frequencies clearly show up in the CLEANed periodograms of the first velocity moment and of the intensity variations across the lines. Furthermore, we find a peak in the periodograms of the moments at 0.17 c/d, corresponding to a period of 6 days.

Henrichs et al. (1993) and Veen et al. (1995) identify the frequency of variations detected in UV wind lines with the rotation period of a magnetic dipole,

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which implies a rotation period of the star of 12 days. We find that the spacings between the main frequency f_1 and the frequencies f_3, f_4, and f_5 are multiples of the frequency detected in the UV wind lines. This means that we can identify the spacing between the frequencies (i.e., $f_1 - f_3 \approx 0.33$ c/d, $f_1 - f_4 \approx 0.17$ c/d, $f_5 - f_1 \approx 0.17$ c/d), as derived from the optical SiIII and OII lines, as multiples of the rotation period.

We find that for the intensity variations across the lines, the pattern of frequencies (f_2, f_3, f_4 and f_5) around the frequency f_1 of the main (radial) pulsation, repeats itself around every detected harmonic of the main frequency, with the same frequency spacing as around the main frequency.

3. Discussion

The pattern of frequency combinations of f_1 and f_2 (i.e., f_1, f_2, f_1+f_1, f_1+f_2, $2f_1+f_1$, $2f_1+f_2$, etc.), as detected in the intensity variations across the lines, can be modelled as a multi-periodic star with l=m=0 and l=m=2 spheroidal modes (Paper I). This model also gives a good description of the observed power and phase distribution across the absorption lines. At present we are investigating if the power and phase distribution of the frequencies f_3, f_4 and f_5 can be modelled as the result of (non-)radial pulsations.

The fact that the spacings of the detected frequencies are multiples of the rotation frequency suggests that the observed variations with frequencies f_3, f_4, and f_5 might be due to modulation effects. The similarities between the variations of UV wind lines and optical lines suggest that either a common phenomenon in wind and photosphere (e.g., a magnetic field) causes these similarities or that one type of variation (wind variability) may be caused by the other (pulsations).

Further investigations will hopefully show whether the variations with frequencies f_3, f_4, and f_5 in the spectra of β Cephei are best described as (non)-radial pulsations, or as the result of modulation caused by the combination of rotation, pulsations and the presence of a magnetic field.

References

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