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Short-term Periodicity in the Pole-on Be Star υ Cyg

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Abstract. The pole-on Be star υ Cyg (HD 202904) displayed with Hipparcos photometry a strong long-lived outburst between 1989 and 1993. High S/N spectroscopic observations were obtained in August-September 1998. The photospheric λ6678 line is strongly perturbed by variable outer V and R emission components and is itself highly variable.
All the studied quantities (profiles, EW, radial velocity of the line centroid, V and R emission components, V/R ratio) are dominated by $\nu =$ 1.5 c/d frequency. The first harmonic ($\nu = 3.0$ c/d) is also detected in the central part of the profile. In the *nrp* frame, this pair of frequencies corresponds to a low degree sectorial g-mode $l = |m| = 2$. Moreover mid-term variations are superimposed to short ones.

1. Introduction

υ Cyg (HD202904, B2V) is a Be star seen under a rather moderate inclination. Some discrepancy can be noted in $v\sin i$ determinations; 254 km/s is referenced at CDS and 180 km/s in Slettebak (1982). The Hα line profile has most often revealed a single peak structure which is consistent with a low inclination.
No rapid variability in light curves has been already detected from ground based observations. According to Hubert & Floquet (1998), Hipparcos photometry between mid 1989 and mid 1993 has shown a strong long-lived outburst (Fig.1) characterized by an increase in brightness (ΔHp = 0.2 mag) over 100 days followed by a gradual decrease over 400 days. Rapid variability with possibly several periods has been suspected in these data; a short period (P=1.13 d, ν=0.86 c/d) could be derived from the set of data obtained prior to the outburst. In addition, some rapid changes in Hα were reported by Ballereau et al. (1987).

2. The observations

HeI 6678 was monitored in 1998 August-September at Haute Provence Observatory with the spectrograph Aurelie (R=22000, 114 spectra) and 2 Hα spectra

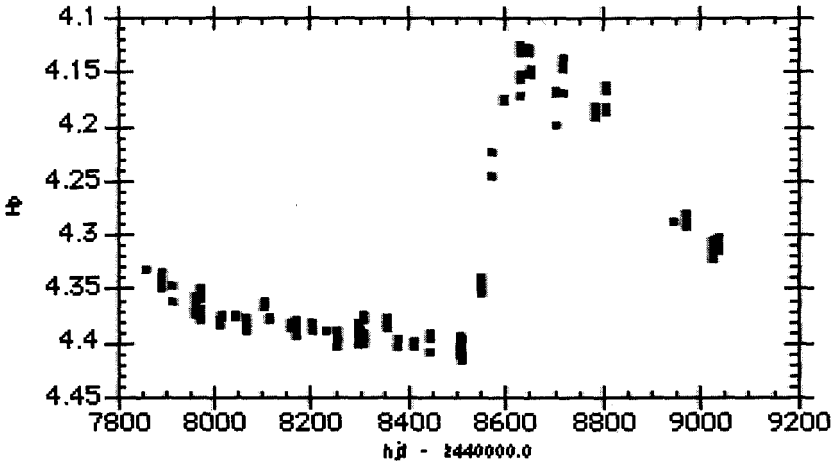

Figure 1. Hipparcos photometry of v Cyg

were also recorded. The search for periodicities was made on the equivalent width, the radial velocity of the centroid of the observed photospheric contribution, the V and R emission components, and in the full line profile (*lpv*) with both TF + Clean and Least Squares sinusoidal fitting methods.

3. HeI line

HeI 6678 has shown a broad photospheric contribution and V and R emission components. It has been noted that due to a veiling effect by the circumstellar matter the "observed" photospheric contribution is notably weaker than the theoretical profile provided by TLUSTY code for a B2V star rotating with $v\sin i$ = 254 km/s. This line is strongly variable essentially in V and R emissions which fluctuate rapidly, the V component showing several minima and maxima. The core of the line is also variable with splittings and changes in asymmetry.
All the measured quantities and *lpv* are dominated by the f=1.5 c/d frequency. Its power is mainly strong in V and R emission components. It is to be noted that values of frequencies are slightly different in V and R as in μ Cen (Rivinius et al. 1998), the R frequency being higher than the V one. V and R components also display a mid-term variation clearly visible on the quantity $I(\mathrm{V}) + I(\mathrm{R})$ over the run (Fig. 2).
Residues, formed by subtraction of a mean profile from individual ones, clearly show a "net-structure" (Fig. 3) due to the fact that the star is seen at a low inclination angle. Blue-to-red travelling features come from the region of the star "above" the visible pole while red-to-blue features originate from regions on the star above the pole moving in the reverse direction. This effect cannot be expected from star spots (Baade, 1992). Hubert et al. (1997) have observed a similar behaviour in 48 Per, another Be star seen at moderate inclination (Hubert et al. 1997).

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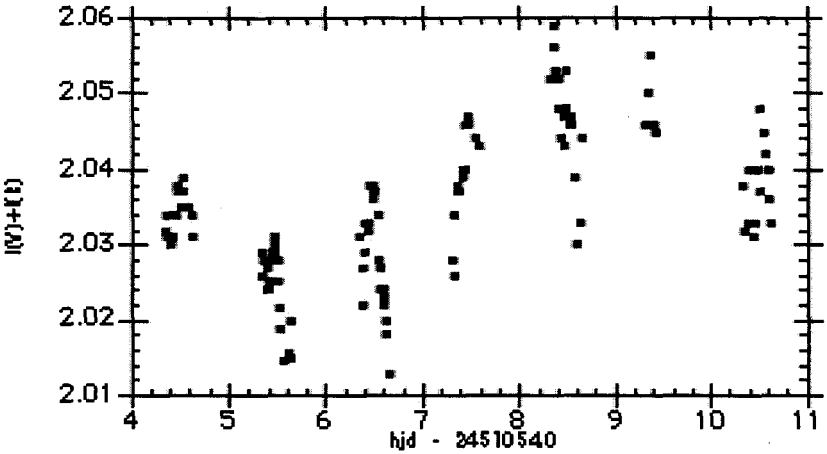

Figure 2. HeI 6678: variation of $I(\mathrm{V})+I(\mathrm{R})$ over the run.

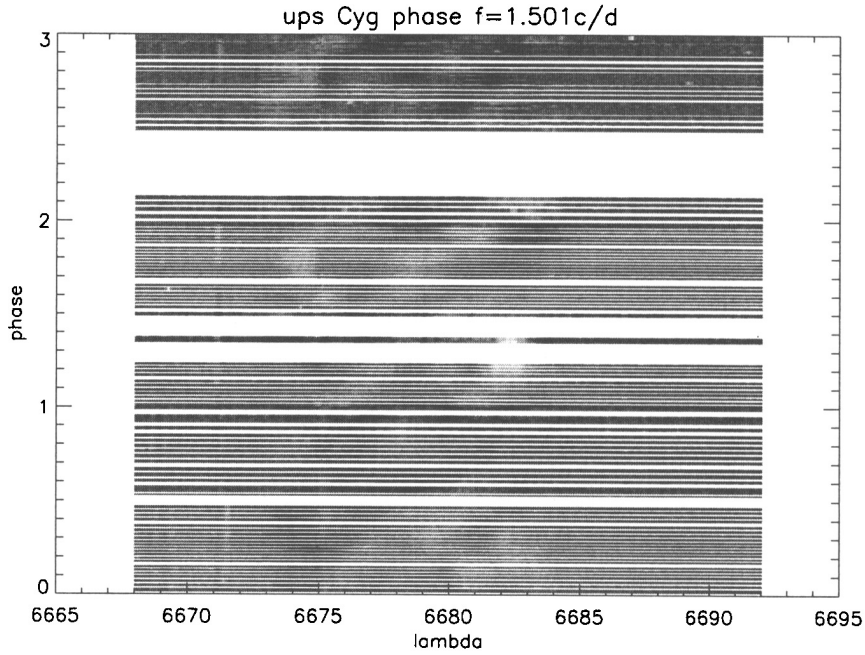

Figure 3. Gray scale residues showing the "net-structure" i.e. bumps crossing the profile from blue to red and from red to blue. To take into account the mid-term variation, phases 0 to 1 represents the 2 first days of the run, phases 1 to 2 the two following ones and phases 2 to 3 the 3 last days of the run. Phases correspond to $\nu = 1.5$ c/d.

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4. Discussion of detected frequencies

Among the detected frequencies two could only be taken into account due to strong aliases in mono-site data.

4.1. 1.5 c/d frequency

This frequency is predominant in all the studied quantities. In the profiles, its power distribution shows a strong intensification at the level of V and R emission components. These emission peaks are located at $\pm 0.70 v \sin i$ if we adopt the value 254 km/s for the projected rotational velocity. The total extension of the power is -250 to $+280$ km/s which corresponds to $\pm v \sin i$ centered on the stellar radial velocity $+10$ km/s.

4.2. 3.0 c/d frequency

This frequency could be the first harmonic of the 1.5 c/d one. Its power is rather well distributed in the whole profile except in the V component where it is very low; as in the case of the fundamental frequency it ranges between -250 and $+280$ km/s. It can be observed an inversion of the slope in the phase distribution at the level of the R component. The same phenomenon is found for one of the frequencies detected in EW Lac (Hubert et al. 1999). In the frame of *nrp* this couple of frequencies could correspond to a g-mode $\ell = |m| = 2$.

5. Hα line

In 1998 August, this emission line was strong ($I_{max} = 6.2$ and EW $= -33.96$ Å). V and R emissions were not resolved but the V component was clearly stronger. Thus, V/R>1. The scarce data found in the literature seem to indicate that our observations were obtained when the Hα intensity reached maximal values.

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