A CCD SPECTROSCOPIC ORBIT AND LINE-VARIABILITY NEAR PERIASTRON FOR HD 193793

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Abstract. Since 1987 we have been observing long-period WR binaries about once every two months with the 1.6m telescope at Observatoire du mont Mégantic. The spectra cover the range $\lambda\lambda \sim$ 4000–6000Å with 2-pixel resolution (~2.5Å) and S/N ~ 500 in the strongest line-peaks. We present a new orbit obtained from several lines in the WC7 and the O4–5 components of the binary system HD 193793 (WR140) and discuss emission-line variability especially in the 2-3 month interval around periastron.

1. Introduction

HD 193793 (WR140, WC7+O4-5) is well known to be a widely separated and eccentric binary system ($a \approx 3180$ R$_\odot$, $e \approx 0.84$, Williams *et al.* 1990). The first periodicity was found by Williams *et al.* (1987) from repeated infrared outbursts: P = 7.94 yr (2886 d). Later, Williams *et al.* (1990) with new infrared data found an improved period of 2900±10 d. The most remarkable phenomenon in this system is the ~2.5 mag increase of the infrared continuum emission near periastron, a direct consequence of the formation and heating of dust, probably in the shock-cone formed by the interaction of the two strong winds.

2. Observations and analysis

CCD-spectroscopic observations have been carried out at Observatoire du mont Mégantic about every 2 months since 1987 using the 1.6m telescope. The spectra cover the ranges 4300–5000Å and 5300–6000Å at 1.25Å/pixel and S/N $\geq$ 300/pixel in the continuum. The reduction and analysis of the spectra were carried out using IRAF (Image Reduction and Facility from NOAO). Radial velocities were determined by fitting a Gaussian profile to the round-shaped emission lines and the absorption lines.

3. Orbital parameters of HD 193793

We measured the He II 5411Å absorption line and the C IV 5801,5812Å emission line blend. The orbital parameters of the two stars in HD 193793 are listed in Table I. The velocity curves fitted to the data are shown in Figs. 1 and 2. The present orbital parameters are in good agreement with the values in the literature, except ω, which is ~ 23° higher.

4. Line-variability in HD 193793

Near periastron (23-27 March 1993), we observed an increase in the red part of the C III 5696Å flat-topped emission line. Fig. 3 shows different spectra

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TABLE I
Orbital parameters of HD 193793

parameter	He II 5411Å absorption	C IV 5806Å emission
P (d)	2900	
e	0.82 ± 0.02	0.84 ± 0.03
$\gamma(\mathrm{km\,s^{-1}})$	8.1 ± 2.2	-92.7 ± 2.6
K $(\mathrm{km\,s^{-1}})$	21.7 ± 4.8	50.1 ± 6.5
$\omega(°)$	52 ± 4	238 ± 2
$T_0(2\,440\,000+)$	6167 ± 7	6158 ± 4

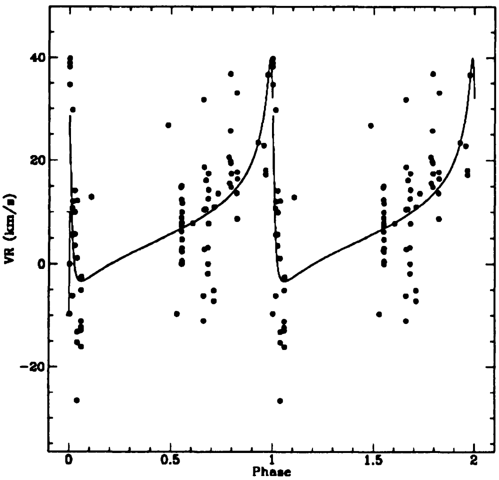

Fig. 1. Velocity curve for He II 5411Å

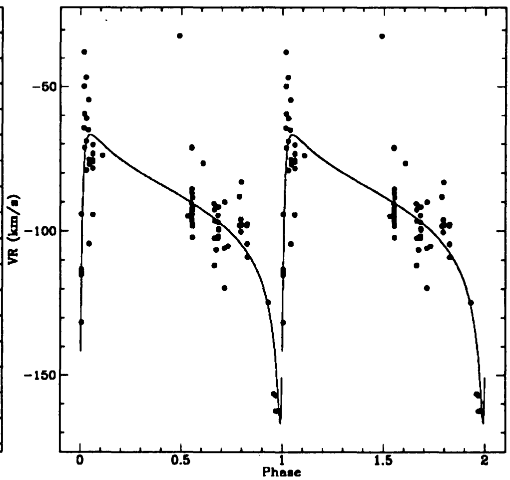

Fig. 2. Velocity curve for C IV 5806Å

at different phases.

We explain this behavior by a simple model of shock-heated material which radiates this line as it cools and flows out with the wind. Since these spectra lie in a range of phases where the WR star was in front of the O-component, the shock-cone was directed away from the observer and the C III excess was red-shifted. Fig. 4 shows the shock-cone of the system at different phases. The shock-cones were computed assuming flux momentum equilibrum between the two winds.

We have measured the equivalent width of C III 5696Å and plotted it *vs.* orbital separation of the stars. This study indicates a clear dependence on the separation. If we assume that both winds are at their terminal velocity for all

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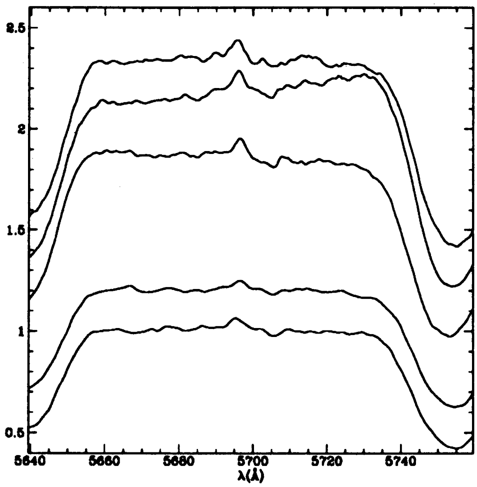

Fig. 3. C III 5696Å at different phases: $\phi = 0.712, 0.826, 0.978, 1.003, 1.028$ from bottom to top. Note the increase in the red part at $\phi = 1.003$.

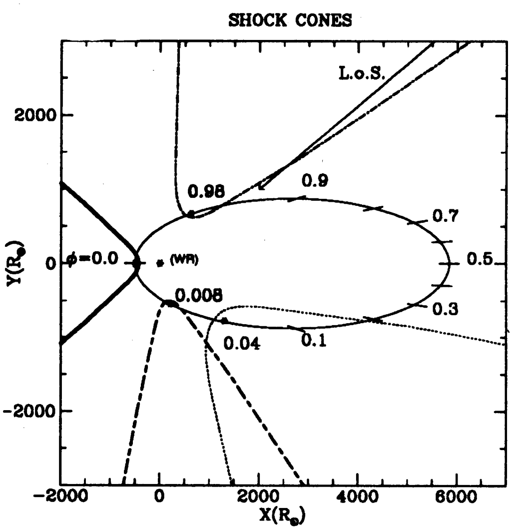

Fig. 4. Shock-cones for different phases

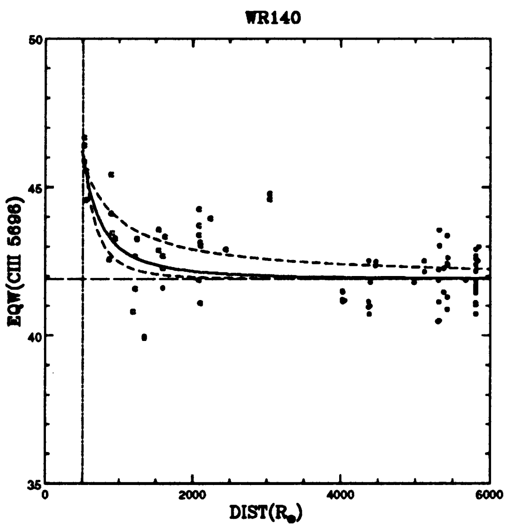

Fig. 5. Equivalent width *vs.* orbital separation. The three lines are $R^{-\alpha}$ plots with $\alpha = 1,3$ for the dashed ones and $\alpha = 2$ for the solid one.

phases (the separation is always greater than 500 $R_\odot$), the only parameter that remains is the density which decreases with a R^{-2} law. As shown in

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Fig. 5, it appears that the dependence varies with some kind of $R^{-\alpha}$ law, with $\alpha = 2$ being the best fit. More spectra near periastron are needed for a better analysis of this behavior.

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DISCUSSION:

van Kerkwijk: 1. Are the errors you quote single-parameter errors or do they include the fact that e.g., e and ω are dependent?
2. What is the reduced χ^2 for the orbital fit?

Hervieux: 1. The errors of each parameters are correlated with each others. But as I mentioned, the period is adopted so the error on the periastron passage is strongly affected by this choice.
2. The χ^2 for the fit is 1.6.

Koenigsberger: What is the approximate width in rm/s of the "bump" superposed on the CIII line you presented?

Hervieux: The edge of the line is at ~ 2000 km/s, so with the beginning of the increase at the center of the line, the width is about 2000 km/s.

Seggewiss: Perhaps you have photometrically calibrated spectra. Then it might be worthwhile also to look for variability in the continuum (though absolute photometry is pretty difficult in your climate).

Hervieux: No, I don't have photometric spectra. The weather in Megantic don't allow us to do this type of observation, it will be a waste of time.

Hillier: The example CIII profile you showed (not at periastron) is a good example of a typical CIII 5696 profile in early WC stars. The profile is very "flat topped". Any model that invokes a disk for the W-R wind in this system must also be able to explain the shape of this line.
In addition, any general model that uses disks to explain the spectra of WC stars in general, must be able to explain why the CIII 5696 line is "flat topped" in all (most) early WC stars.

Moffat: In your plot of equivalent width versus separation, you noted an asymmetry between going in to versus coming out of periastron. I wonder if this could be related to the inclined disk that was mentioned by R H Becker? (Note that according to them, the O-star will plunge through the disk near periastron passage).

Hervieux: Maybe, but in the disk model you should have a very narrow increase of the equivalent width when the disk goes through the plane of the O stars. Here, we see a long decrease with the separation which should be related with a long interaction. So to have a long interaction, you need a big angle of inclination. This angle has to be found to answer properly to this question, if it's a disk.