SPECTROSCOPIC OBSERVATIONS OF THE LONG–PERIOD WOLF-RAYET BINARIES HD 193793 AND HD 192641

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Abstract. New medium–resolution spectroscopic observations of two long–period WR binaries have been obtained using the 1.5 m telescope at the Tartu Astrophysical Observatory. The binarity of these systems is confirmed and orbital parameters are determined.

Key words: Wolf–Rayet stars – Binaries – Radial velocities

1. Introduction

The prototype of the stars showing strong IR variations and dust formation is HD 193793 (WC7+O4–O6). Its binarity was doubted for a long time. The first attempt to determine an orbit was made by Lamontagne *et al.* (1984) but Conti *et al.* (1984) found no orbital motion. Some years later Williams *et al.* (1987b) detected from IR photometry the period of 2885 d. This period was confirmed in further investigations by Moffat *et al.* (1987), Williams *et al.* (1990) and Annuk (1991). Another outstanding star of this class is HD 192641 (WC7+O9). Previous radial velocity measurements by Massey *et al.* (1981) and Moffat *et al.* (1986) have not given any periods. From IR photometry Williams *et al.* (1987a) suggested that the possible period is about 4400 d. This period was supported by our radial velocity measurements (Annuk 1991). Recently, Underhill (1992) put its binarity under suspicion claiming that radial velocities were constant.

2. Obervations

The spectroscopic observations were carried out at the Tartu Astrophysical Observatory using a 1.5 m telescope with a Cassegrain spectrograph ASP–32 (at a reciprocal dispersion of 37 Å/mm or 18 Å/mm). Radial velocities of the strongest emission line, C IV λ4650 were computed by the method of bisector. Radial velocities of other emission lines and absorption lines were determined by fitting the Gaussian profiles or the parabola upon the normalized intensity profiles.

3. HD 193793

New additional spectra were obtained around the last periastron passage in the years 1991–93. Radial velocities of absorption were calculated as a mean of several strong absorption lines. Typical 1σ limits of averaging were 8–10 km/s. Radial velocities of the emission line C IV λ4650 were calculated as a mean of the levels I/I_c=0.55–0.80 (1σ=10–15 km/s). Around the peri-

K. A. van der Hucht and P. M. Williams (eds.), Wolf-Rayet Stars: Binaries, Colliding Winds, Evolution, 231–234.

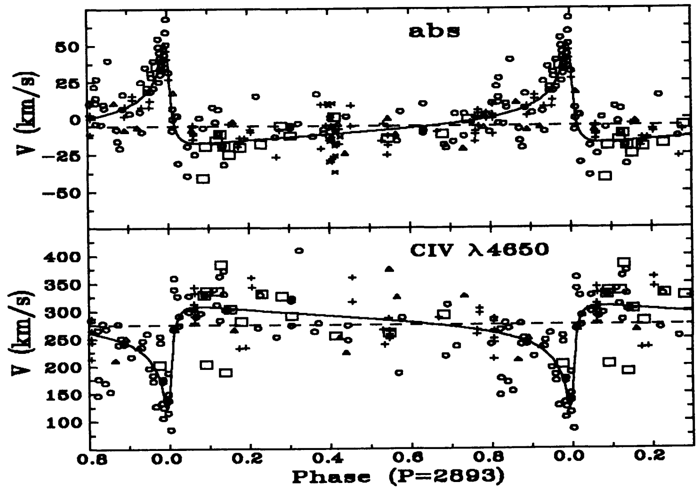

Fig. 1. Velocity curves of HD 193793. o – this paper; + – Conti *et al.* (1984); ⊓ – Lamontagne*et al.* (1984); △ – Moffat et al. (1987); × – Galkina (1970).

astron passage we can see clear antiphase variations of the absorption line velocities (v_{abs}) and emission line velocities (v_{em}). Immediately after the periastron passage the v_{abs} very quickly decrease but v_{em} increase. During a month $\Delta v \approx$-50 km/s for absorption and $\Delta v \approx$140 km/s for emission. Such variations very strongly support the hypothesis of a very eccentric (e = 0.85) binary system. By using our new and all available observations we derived new orbital elements (see Table 1). The corresponding radial velocity curves are plotted in Figure 1. Our new elements do not differ from those found earlier by Williams *et al.* (1990) and by us (Annuk 1991). We found that the last periastron passage took place on February 17(±4), 1993. Using the infrared data (*e.g.* Williams *et al.* 1990) we can conclude that the IR maximum (at 3.8 μm) appears about 50 days (in phase $\sim$ 0.017) after the periastron passage. The minimum distance between the WR and the O component is $d \sin i \approx 568$ $R_\odot$ and the mass ratio $q = 0.37 \pm 0.04$.

4. HD 192641

Radial velocities of the strongest emission line were calculated as a mean of the levels I/I_c=0.45-0.70 (1σ=7-11 km/s). We were able to measure radial velocities of some other emission lines (*e.g.* C IV λ4441, C IV λ4786 and C III λ4069) but the accuracy was somewhat worse. Although the absorption lines are weak we have measured the radial velocities from better spectrograms. 1σ limits for the absorptions were 20-30 km/s. Our new radial velocities of the line C IV λ4650 do not fit with our previous orbital elements (Annuk 1991). If we assume that the period is about 4400 d as it was indicated from

TABLE I
Orbital elements of HD 193793.

Element	abs	C IV λ4650
P (day)	2893	2893
e	0.85±0.01	0.85
γ (km/s)	−5.1±0.5	275.5±2.3
K (km/s)	33.8±1.5	91.3±4.8
ω(°)	40.8±3.1	220.8
T_0 (2440000)	9036±4	9034±5
$a \sin i$ ($R_\odot$)	1022±46	2750±144
$m \sin^3 i$ ($M_\odot$)	62.7±9.6	23.2±3.4
σ (km/s)	8.6	32.5

TABLE II
Orbital elements of HD 192641.

Element	C IV λ4650	abs
P (day)	5680	
e	0.07±0.03	0.07
γ (km/s)	80.7±0.7	0.2±2.3
K (km/s)	30.5±1.1	21.6±3.7
ω(°)	380±24	200
T_0 (2440000)	6017±380	6017
$f(m)$ ($M_\odot$)	16.6±1.7	
σ (km/s)	6.4	18.7

an earlier infrared curve then the orbit must be more eccentric ($e \geq 0.55$). Thus in this case there is a slight disagreement with the velocities measured by Moffat *et al.* (1986) in 1981 and with our recent measurements. Another way is to assume that the period is longer than 4400 d. In this case there is a disagreement in the infrared curve, although new IR measurements indicate a longer period (Williams 1994, these proceedings). From all available data we found a new possible period of 5680 d. Our new derived orbital elements are given in Table 2 and the corresponding curves are plotted in Figure 2. In this Figure we have also plotted the radial velocities of the measurements of Underhill (1992). It must be said that her velocities of the line C IV λ4650 coincide very nicely with our velocities. We need to add only some correction of about 70 km/s to Underhill's velocities for bringing her data into good agreement with our values. This correction is mainly caused by the fact that she calculated the velocities with respect to λ4651.56 but we with respect to λ4650.16. As we can see from Figure 2, the absorption line velocities are very scattered and therefore the solution for absorption is quite uncertain.

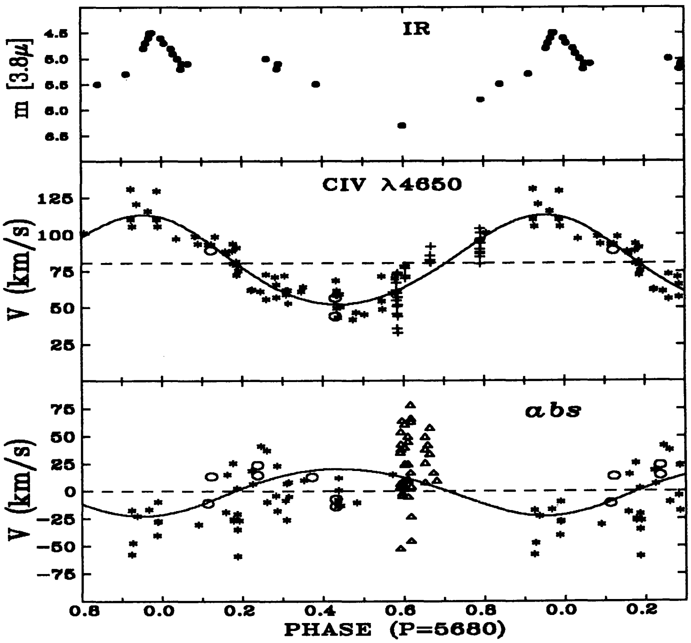

Fig. 2. Velocity curves of HD 192641. ∗ – this paper; + – Moffat *et al.* (1986); △ – Massey *et al.* (1981). IR photometry based on the paper of Williams *et al.* (1987a).

More observations are needed for this star.

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DISCUSSION:

Moffat: Do you see any phase-dependent time profile variations, especially around periastron passage, when wind interaction effects are expected to be important?

Annuk: No, we didn't find such variations.

https://doi.org/10.1017/S007418090020199X Published online by Cambridge University Press