RevMexAA (Serie de Conferencias), **5**, 108–110 (1996)

SEARCH FOR INTERACTING WINDS IN THE WN7 + O BINARY WR 22 [1]

Gregor Rauw[2], Jean-Marie Vreux, and Eric Gosset[3]
Institut d'Astrophysique, Université de Liège,
5, Avenue de Cointe, B-4000 Liège, Belgium

RESUMEN

Presentamos observaciones de la línea He I λ5876 en el espectro del sistema binario WR 22, obtenidas alrededor del periastro. Estos datos demuestran una variabilidad importante del perfil de la línea. Utilizamos nuevos elementos orbitales para discutir la posibilidad de una interacción de mareas o de un fenómeno de colisión entre los vientos afectando la parte externa de la atmósfera Wolf-Rayet.

ABSTRACT

We present new spectroscopic observations of the He I λ5876 line in WR 22 which were obtained around periastron. These data show strong line profile variability. We use recently determined orbital elements of WR 22 to discuss the possibility of tidal interactions or of a colliding wind phenomenon affecting the outer parts of the Wolf-Rayet atmosphere.

Key words: **BINARIES: SPECTROSCOPIC — STARS: INDIVIDUAL: WR 22 — STARS: MASS LOSS — STARS: WOLF-RAYET**

1. INTRODUCTION

WR 22 (≡ HD 92 740), a Wolf-Rayet star of spectral type WN7+abs, was classified as a single-line spectroscopic binary with a period of 80.3 days (van der Hucht et al. 1988). Later on, it was shown that WR 22 is an eclipsing binary (Gosset et al. 1991), with only the "secondary" eclipse being visible (corresponding to the WR in front of its companion). In a recent paper (Rauw et al. 1996), we reported the detection of some weak absorption features which, for the first time, can be definitely attributed to the companion. These absorption lines allow a spectral classification of the secondary as a "late O star" (O6.5–O8.5). However, no firm conclusion could be achieved about the luminosity class of the companion. We derived a new radial velocity curve for the WN7+abs primary, allowing us to significantly improve the orbital parameters of WR 22, formerly determined by Moffat & Seggewiss (1978) and Conti et al. (1979). The orbit is quite eccentric (e=0.56), with a semi-major axis $a \sin i$ of 360 $R_\odot$ and an argument of periastron $\omega = 272°$, indicating that the periastron passage and the eclipse nearly coincide. From the RV curve of the companion, we found the minimum masses of both stars to be $m_{\rm WR} \sin^3 i = 71.7 \pm 2.4\ M_\odot$ and $m_{\rm O} \sin^3 i = 25.7 \pm 0.8\ M_\odot$ (Rauw et al. 1996). Thus, the WN7+abs primary is the most massive WR ever found, and is probably a core hydrogen-burning object, whose external layers have been peeled off, leading to reduced H and enhanced He and N abundances at the surface (Rauw et al. 1995).

2. OBSERVATIONS

The spectra of WR 22, covering the wavelength range from 5400–6150 Å were obtained during a 7 night observing run around the periastron passage of March 1995 with the ESO 1.5-m telescope equipped with a Boller & Chivens Cassegrain spectrograph. The detector was a Ford Aerospace 2048L UV-coated CCD with a

[1] Based on observations collected at the European Southern Observatory (La Silla, Chile).

[2] Aspirant au Fonds National de la Recherche Scientifique (Belgium).

[3] Chercheur Qualifié au Fonds National de la Recherche Scientifique (Belgium).

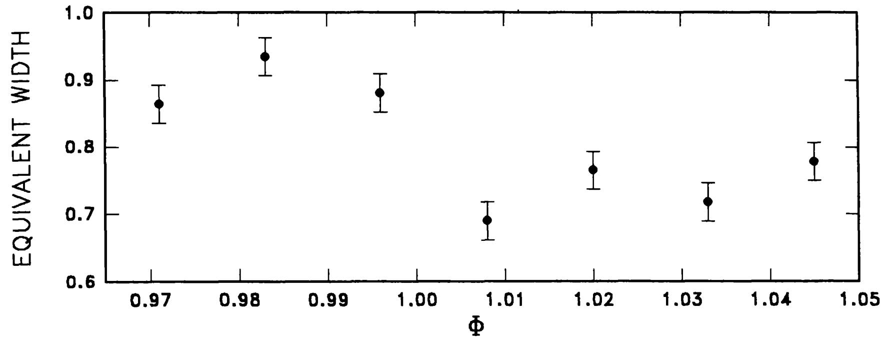

Fig. 1. Variations of the equivalent width (in Å) of the absorption component of the He I λ5876 line in the spectrum of WR 22 around the periastron passage of March 1995.

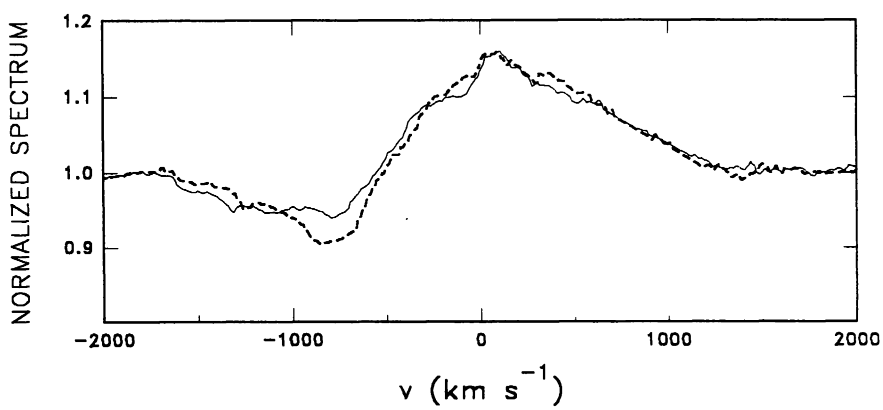

Fig. 2. Variations of the "restored" He I λ5876 line in the normalized spectrum of WR 22 around the periastron passage of March 1995. The spectra have been corrected for the orbital motion of the WN7+abs primary. The spectrum taken at phase $\phi = 0.008$ (solid line) is compared to the one taken at $\phi = 0.971$ (dashed line).

square pixel size of 15 μm. The grating used was ESO #32 (holographic grating, 2400 lines/mm) providing a reciprocal dispersion of 32.6 Å/mm. The slit width was set to 220 μm, corresponding to 2″ on the sky.

The spectra were corrected for the telluric absorptions between 5860 and 5980 Å, and were normalized to the continuum using a polynomial fit through selected continuum windows. The individual observations were corrected for the orbital motion of the WN7+abs primary, before they were averaged to get the mean spectrum of the night. The S/N ratio of the mean spectra is $\sim$ 150 except for the second night (S/N $\sim$ 80).

The measured equivalent widths of the He I λ5876 absorption component (corrected for the continuum eclipse light curve) are plotted in Fig. 1 as a function of the orbital phase. The variability of the He I profile is illustrated in Fig. 2. For the sake of clarity, the original He I profiles were "restored" by removing the interstellar Na I absorption lines at 5844 and 5849 Å. The red wing of the emission remains relatively stable, but one has to bear in mind that a weak variability could be masked by the effects of the strong interstellar absorptions and of the residuals of the telluric absorptions. The emission peak exhibits marked variations that are partly due to the blend with the absorption line of the secondary.

The absorption component of the WR line exhibits strong variability during our observations. After periastron, one sees a shallow, flattened absorption component comparatively to the profile before periastron (as illustrated in Fig. 2). At the same time, the minimum of the absorption is progressively shifted by about 300 km s^{-1} towards the blue, while the EW of the absorption drastically decreases (Fig. 1). The decrease of the EW results from a reduction of the absorption between −550 km s^{-1} and −1250 km s^{-1}, which is much stronger than the slight enhancement of the absorption shortwards of −1250 km s^{-1}. Variations are also observed in the slope of the red wing of the absorption component.

3. TOWARDS A POSSIBLE INTERPRETATION...

Although the variations reported above occur in a portion of the WR wind located at a polar angle of 140° – 240° with respect to the axis of the binary, they could be linked to some interaction between the two stars in an indirect way. The shallow, flattened absorption component of the P-Cygni profile, seen around ϕ=0.0 (i.e., when the absorption arises at a polar angle of ~180°), could indicate a dependence of the mass loss rate per unit solid angle $d\dot{M}/d\Omega = r^2\rho(r)v_r(r)$ on the relative angular position and distance of the secondary. Friend & Castor (1982) predict such an angular dependence for the mass loss rate of the OB primary in high-mass X-ray binaries. The asymmetry of their wind model is due to the combined effects of the gravitational force and of the radiation pressure of the secondary. In the case of WR 22, an alternative explanation for this behaviour could be a variation of the ionization balance due to the occultation of the O star by the WR. However, this latter scenario alone is not sufficient to explain the observed asymmetry of the He I line profile variability (with respect to the phase ϕ=0.0).

Assuming either a giant or a main sequence luminosity class for the secondary and adopting the parameters of Hamann et al. (1991) for the WN7 primary, one gets a mean ratio of the WR wind momentum to the O wind momentum of 50 – 100. Under these conditions, the WR wind would most probably collide with the O star surface. However, in some WR + O binaries, radiative braking can significantly alter the strength and geometry of the interaction zone (Owocki & Gayley 1995; Gayley et al. 1996). In the case of WR 22, radiative braking will lift the shock off the O star surface and support a wind/wind collision around periastron that otherwise would not exist (Gayley, private communication). This will lead to a considerable widening of the opening angle of the shock front and could also contribute to an asymmetric density distribution through the WR wind.

Of course, one cannot rule out the possibility of a sporadic, intrinsic variability of the WR wind, and more data are needed to ascertain the origin of the reported line profile variations. Nevertheless, among the possible interpretations, a binary interaction scenario is probably one of the most appealing.

The authors are greatly indebted to the Fonds National de la Recherche Scientifique (Belgium) for multiple supports. This research is also supported in part by contracts ARC90/94-140 and ARC94/99-178 "Action de Recherche Concertée de la Communauté Française" (Belgium), and by contract SC005 of the Belgian programme "Service Centers and Research Networks" initiated by the Belgian State, Prime Minister's Office, Science Policy Programming under SSTC. Partial support through the PRODEX XMM-OM Project, and the "Fondation Agathon de Potter" is also gratefully acknowledged.

REFERENCES

Conti, P. S., Niemela, V. S., & Walborn, N. R. 1979, ApJ, 228, 206

Friend, D. B., & Castor, J. I. 1982, ApJ, 261, 293

Gayley, K. G., Owocki, S. P., & Cranmer, S. R. 1996, in Colliding Winds in Binary Stars, ed. V. Niemela & N. Morrell, RevMexAASC, 5, 68

Gosset, E., Remy, M., Manfroid, J., Vreux, J.-M., Balona, L. A., Sterken, C., & Franco, G. A. P. 1991, IBVS, 3571, 1

Hamann, W.-R., Dünnebeil, G., Koesterke, L., Schmutz, W., & Wessolowski, U. 1991, A&A, 249, 443

Moffat, A. F. J., & Seggewiss, W. 1978, A&A, 70, 69

Owocki, S. P., & Gayley K. G. 1995, ApJ, 454, L145

Rauw, G., Vreux, J.-M., Gosset, E., Hutsemékers, D., & Magain, P. 1995, in 32nd Liège Int. Astroph. Coll., Stellar Evolution: What Should Be Done, ed. A. Noels, D. Fraipont, M. Gabriel, N. Grevesse, P. Demarque, 463

Rauw, G., Vreux, J.-M., Gosset, E., Hutsemékers, D., Magain, P., & Rochowicz, K. 1996, A&A, 306, 771

van der Hucht, K. A., Hidayat, B., Admiranto, A. G., Supelli, K. R., & Doom, C. 1988, A&A, 199, 217