

The massive Wolf-Rayet binary WR 98 (WN7/WC+O8-9)

Roberto C. Gamen¹ and Virpi S. Niemela²

Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Paseo del Bosque s/n, B1900FWA, La Plata, Argentina

Abstract. We present the discovery of OB type absorption lines superimposed to the emission line spectrum, and the first double-lined orbital elements, for the massive Wolf-Rayet binary WR 98 (HDE 318016, WN7/C+O8-9), a spectroscopic binary in a circular orbit with a period of 47.825 d. The semi-amplitudes of the orbital motion of the emission lines differ from line to line, indicating a mass ratio in the range $q \equiv M_{\text{WR}}/M_{\text{OB}} = 1 - 1.8$.

1. Introduction and observations

WR 98 (HDE 318016, Tr27-105) is one of the few Wolf-Rayet stars showing both N and C emission lines (van der Hucht 2001), causing its classification WC7-WN6 (Smith (1968), WN7+WC7 (van der Hucht *et al.* 1981), and WN8/WC7 (Smith *et al.* 1996). WR 98 was found to be a single-lined spectroscopic binary, with $P = 47.8$ d and with N and C emission lines moving in phase by Niemela (1991). We present here the results of a detailed radial-velocity (RV) analysis of optical spectral lines of WR 98 (Gamen & Niemela, 2002), showing it to be a double-lined spectroscopic binary (SB2).

We have obtained a total of 69 blue optical spectrograms of WR 98 at CTIO in Chile (1980-84) and CASLEO³ in Argentina (1997-2001). The observations at CTIO were performed with the Cassegrain IT spectrograph on the 1m Yale telescope, using photographic plates with fine grain emulsion as detector. The observations at CASLEO were obtained with the CCD Cassegrain spectrographs attached to the 2.15m telescope. The photographic observations were digitized with a Grant machine at La Plata. The digital data were processed and measured with IRAF routines.

2. Results

Our RV analysis of the optical spectral lines of WR 98, using a long term database, confirms that this star is a binary system with $e = 0$ and $P = 47.825$ d (see Figure 1). N and C emission lines in the spectrum move in phase, indicating

¹Fellow of CONICET, Argentina

²Visiting Astronomer, CTIO, NOAO, operated by AURA, Inc. for NSF, USA. Member of Carrera del Investigador, CIC-BA, Argentina

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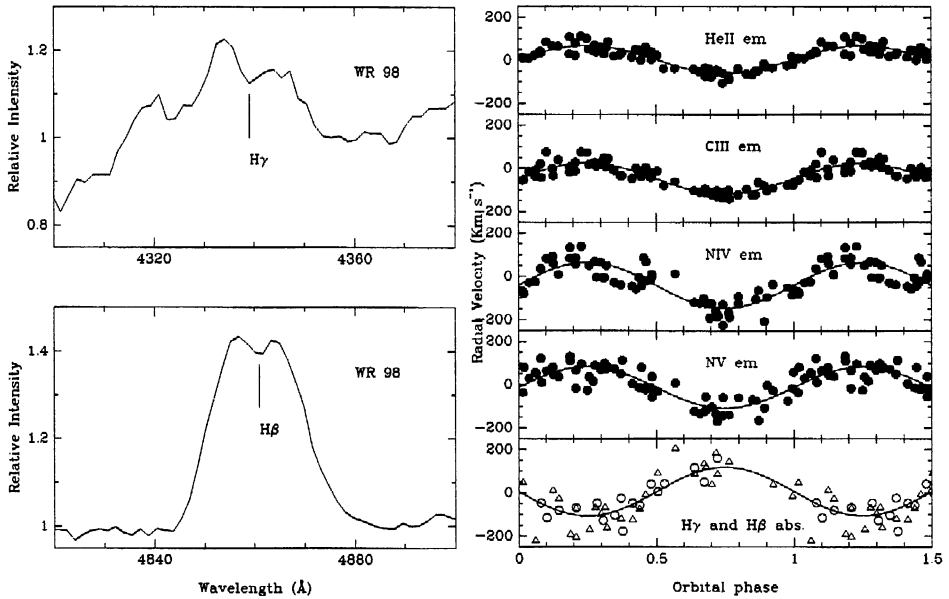


Figure 1. *Left:* H γ and H β absorption in He II emission of WR 98. *Right:* RV variations of emission lines and absorption of H γ (circles) and H β (triangles) phased with $P = 47.825$ d. Curves represent orbital solutions from Table 1.

Table 1. Circular orbital elements of WR 98 (WN7/WC+O8-9, $P = 47.825$ d).

element	N IV em.	N V em.	C III em.	He II em.	absorptions
V_0 (km s $^{-1}$)	-41 ± 4	-15 ± 3	-47 ± 2	4 ± 2	6 ± 15
K (km s $^{-1}$)	106 ± 6	109 ± 5	72 ± 3	65 ± 3	112 ± 16
$M_{WN} \sin^3 i$ (M_\odot)	27 ± 10	28 ± 10	19 ± 8	18 ± 7	
$M_{OB} \sin^3 i$ (M_\odot)	25 ± 7	27 ± 7	12 ± 3	10 ± 3	

that they are formed in the same stellar envelope (see Figure 1). We have also detected absorption lines upon the emissions. These absorptions correspond to a late O8-9 spectrum, and they move anti-phased with respect to the emission lines (see Figure 1). Thus WR 98 is a SB2. Orbital elements are listed in Table 1. The RV variations of absorption and emission lines indicate that M_{WR}^{min} ($\approx 28 M_\odot$) is similar or larger than M_\odot^{min} ($\approx 27 M_\odot$).

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