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WOLF-RAYET BINARIES REVISITED

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RESUMEN

En busca de variaciones espectrales parecidas a las observadas en la binaria WR HD 5980 en la Nube Menor de Magallanes, hemos reobservado los sistemas binarios WN+O galácticos WR 21, WR 31 y WR 47 en CASLEO, San Juan, Argentina. Cuando se los compara con observaciones previas, la morfología espectral de estas binarias no parece haber cambiado. Con nuestros nuevos datos de velocidades radiales de las líneas de emisión en los espectros de la WN, se determinaron períodos más exactos para los tres sistemas. Además, notamos un comportamiento peculiar de la emisión de N IV 4058 Å en los espectros de WR 21 y WR 47. En nuestros nuevos datos, esta emisión sigue la órbita de la componente WN, pero la velocidad media presenta un corrimiento hacia velocidades más negativas respecto de los resultados publicados previamente. Esto podría indicar una mayor expansión en la atmósfera de la componente WN.

ABSTRACT

Searching for spectral variations similar to those observed in the WR binary HD 5980 in the Small Magellanic Cloud, we have re-observed the WN+O binary systems WR 21, WR 31 and WR 47 at CASLEO, San Juan, Argentina. Compared with previous observations, the spectral morphology of these binaries does not appear to have changed. From our new radial velocity data of emission lines in the WN spectra, improved periods are determined for all three binaries. We also report the peculiar behaviour of the N IV 4058 Å emission line in the spectra of WR 21 and WR 47. In our new data, this emission follows the orbital motion of the WN component, but with a mean velocity shifted to more negative values when compared with previous data. This may indicate an enhanced expansion in the atmosphere of the WN component.

Key words: **STARS: BINARIES — STARS: INDIVIDUAL: (WR 21, WR 31, WR 47) — STARS: WOLF–RAYET**

1. INTRODUCTION AND OBSERVATIONS

Since the spectacular spectral changes observed in the Wolf-Rayet (WR) binary system HD 5980 in the Small Magellanic Cloud (cf. Barbá et al. 1995), the obvious question arose: does this kind of spectral variation happen also in other WR binaries? With the aim of checking the behaviour of other WR binaries, we have re-observed three galactic WN+O type binary systems, namely WR 21, WR 31 and WR 47 (WR numbers are from van der Hucht et al.'s 1981 catalogue). We also aimed to obtain improved orbital solutions, since those existing in the literature are based on data obtained more than ten years ago.

Digital spectral images of WR 21, WR 31 and WR 47 were obtained in 1997, March, at CASLEO[2], San Juan, Argentina. We used the B&C spectrograph with a CCD PM 512 × 512 pixels detector attached to the 2.15-m telescope. A grating of 600 lines mm^{-1} used in first order produced a resolution of ~ 2.3 Å $pixel^{-1}$. The spectral images were processed with IRAF routines at La Plata Observatory. One-dimensional spectra were extracted from the CCD images, and the spectra were flat-fielded and wavelength calibrated. Radial velocities were determined fitting Gaussian profiles to the emission lines of the Wolf-Rayet spectra.

Here we present improved orbital solutions for the emission lines, and report on the peculiar behaviour of the N IV 4058 Å emission in the spectra of WR 21 and WR 47.

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2. RESULTS

Our new spectra of WR 21, WR 31, and WR 47 obtained at CASLEO in 1997, March, appear similar to those observed previously. New spectral types for WR 21, WR 31, and WR 47 as WN5o + O4–6, WN4o + O8 V and WN6o + O5 V, respectively, have been recently assigned by Smith, Shara, & Moffat (1996), and our spectra agree with them. Radial velocities of the emission lines determined from our new data show a small phase-shift when plotted with the ephemeris published previously. We have determined improved periods for all three binaries:

WR 21: $P = 8.2546 \pm 0.0001$ d; **WR 31:** $P = 4.8306 \pm 0.0001$ d; **WR 47:** $P = 6.2393 \pm 0.0001$ d

With these periods, new orbital elements for the emission lines where found, as listed in Table 1.

TABLE 1

CIRCULAR ORBITAL ELEMENTS OF WR 21, WR 31, AND WR 47

Parameter		He II 4686			N V 4603			N IV 4058					
WR 21		(a+b)			(a+b)			(a)			(b)		
V_0	[km s^{-1}]	42	±	5	36	±	3	−19	±	7	−112	±	8
K	[km s^{-1}]	250	±	7	209	±	5	229	±	9	216	±	11
T_0	[HJD 2,443,900+]*	8.7	±	0.5	9.34	±	0.02	9.29	±	0.06	9.1	±	0.1
$a \sin i$	[$R_\odot$]	41	±	1	33.9	±	0.7	37	±	2	35	±	2
σ	[km s^{-1}]	34			21			38			19		
$f(m)$	[$M_\odot$]	13	±	1	7.8	±	0.5	10	±	1	9	±	1
WR 31		(c+b)			(c+b)								
V_0	[km s^{-1}]	22	±	4	18	±	3						
K	[km s^{-1}]	213	±	5	183	±	4						
T_0	[HJD 2,445,300+]*	79.74	±	0.02	80.14	±	0.02						
$a \sin i$	[$R_\odot$]	20.2	±	0.5	17.3	±	0.4						
σ	[km s^{-1}]	31			21								
$f(m)$	[$M_\odot$]	4.8	±	0.4	3.0	±	0.2						
WR 47		(d+b)			(d+b)			(d)			(b)		
V_0	[km s^{-1}]	8	±	3	53	±	3	−87	±	3	−159	±	7
K	[km s^{-1}]	261	±	4	276	±	4	266	±	4	281	±	9
T_0	[HJD 2,443,900+]*	13.8	±	0.2	14.03	±	0.02	14.05	±	0.03	14.0	±	0.7
$a \sin i$	[$R_\odot$]	31.9	±	0.5	33.8	±	0.5	32.6	±	0.5	34	±	2
σ	[km s^{-1}]	15			23			22			16		
$f(m)$	[$M_\odot$]	11.4	±	0.5	13.6	±	0.6	12.2	±	0.6	14	±	2

* Time of maximum radial velocity.

Notes: Data from (a) Niemela (1976) and Niemela & Moffat (1982); (b) this paper; (c) Niemela, Mandrini, & Méndez (1985); (d) Niemela, Conti, & Massey (1980); Mandrini (1983).

The radial velocity orbits are shown in Figures 1, 2, and 3. As seen in these figures, N V and He II emissions reproduce well the previous radial velocity orbits. However, in the spectra of WR 21 the emission line of N IV 4058 Å exhibits a considerably more negative systemic velocity than before, as seen in Fig. 1 (left). Also in the spectrum of WR 47 the N IV emission shows somewhat more negative systemic radial velocity, as seen in Fig. 3 (left), but not as much as in WR 21.

We interpret this as an enhanced expansion of the WN atmosphere, which warrants follow-up observations.

We are grateful to the director and staff of CASLEO for the support and hospitality during our observing.

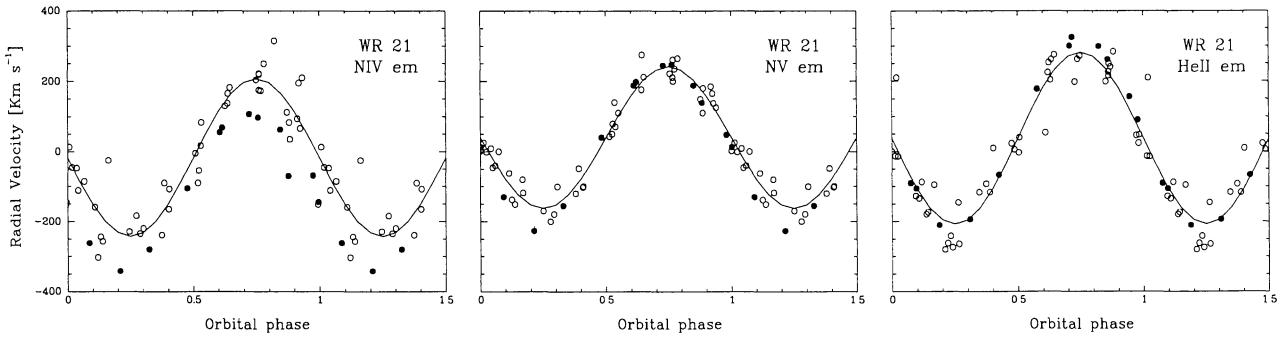

Fig. 1. Radial velocity variations of N IV 4058 Å (left), N V 4603 Å (center) and He II 4686 Å (right) emissions in the spectrum of WR 21, phased with the improved period. Filled circles represent our new CASLEO data, open circles previous observation (cf. Table 1). Continuos lines represent the orbital solutions from Table 1.

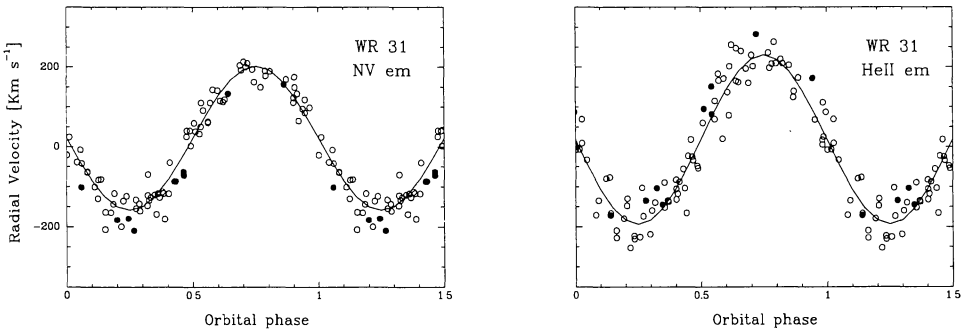

Fig. 2. Idem Fig. 1, but for WR 31. Radial velocity variations of N V λλ 4603 – 4619 (left) and He II 4686 Å (right).

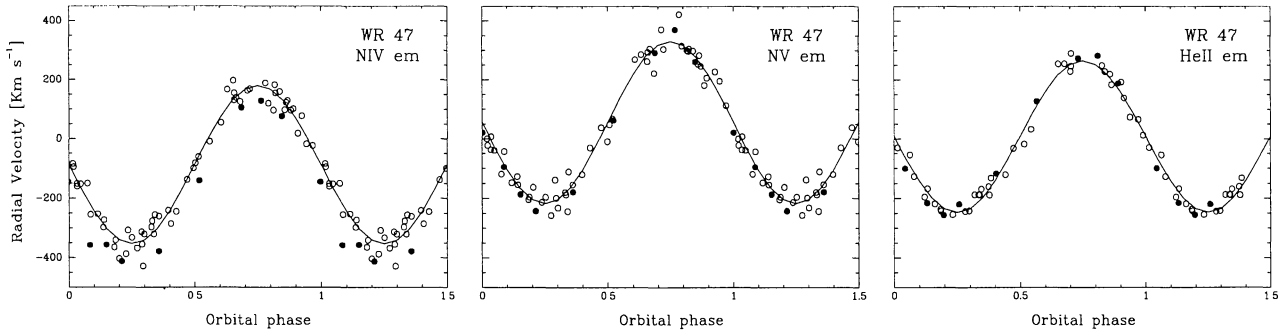

Fig. 3. Idem Fig. 1, but for WR 47.

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