LINES PROFILE VARIATIONS AND BINARITY IN WOLF-RAYET STARS

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The ratio of binaries among the WR stars is subject of many discussions essentially due to two reasons: First, the important role that the presence of a companion can play in the evolution of a massive star and as consequence in the interpretation of the evolutionary phase of the WR stars. Second, the strong difficulty to determine the binarity of the WR stars due to the width of the spectral lines.

Recently, HD50896, a WN5 star, for long time considered as isolated, has been demonstrated to be a binary by Firmani et al. (1980). This star shows very small displacement of the lines due to orbital motion and no evidence of the secondary spectrum. It has been interpreted as a binary system with a collapsed companion. The first evidence of periodical variation in this system have been found analyzing the profile variation of the HeII line λ4686 that are easier to be detected than the displacement of the lines due to the orbital motion.

An evident question can be formulated at this point: is HD50896 a rare system in which the profile variations are peculiarly strong and easy to be detected, or are there many of these undetected binaries for which the analysis of the profile variation may be a powerful method to determine the periodicity? With this problem in mind we have observed a sample of 17 WR stars during a week to analyze both profile and radial velocity variations. This sample includes all the WR stars with $M_V<12$ and $0°<\ell^{II}<80°$ except for five stars that are binaries with determined period. All the spectra have been taken with a dispersion of 1.1 Å channel^{-1} using a SIT television camera and a low dispersion spectrograph attached to the 2-meter telescope of the Observatorio Astronómico Nacional in San Pedro Mártir, Baja California (México).

The observational season has been too short to obtain definitive results on the binarity of each star. What we have done is to define the probability of each star to be binary. This probability is defined as proportional to the intensity of the variations of the profiles and radial velocity of the lines and their coherence with a possible period.

C. W. H. de Loore and A. J. Willis (eds.), Wolf-Rayet Stars: Observations, Physics, Evolution, 583–587.

TABLE 1

N	Profile Variation	Central Wavelength Variation	Probability
86 WC7	CIIIλ4650 strong	----------	((binary))
93 WC6	----------	----------	no binary
103 WC9	CIIIλ4650 weak	CIIIλ4650,Δλ≃1 Å HeIIλ4686,Δλ≃1 Å irregular	(((binary)))
108 WN6	Blend λ4650 strong P>7d	HeIIλ4686,Δλ≃1 Å HeIIλ4541,Δλ≃1 Å P>7d	((binary))
110 WN6	HeIIλ4686 strong P≃4d	HeIIλ4686,Δλ≃1 Å P≃4d	(binary)
111 WC5	CIIIλ4650 strong P>7d	CIIIλ4650,Δλ≃2 Å irregular	((binary))
121 WC9	----------	----------	no binary
123 WN8	NIIIλ4640 weak HeIIλ4680 weak	NIIIλ4640,Δλ≃1 Å HeIIλ4686,Δλ≃1 Å irregular	(((binary)))
127 WN4+09	HeIIλ4686 medium P>7d	HeIIλ4686,Δλ≃1.5 Å HeI 4471_{abs},Δλ≃1.5 Å P≃10d	(binary)
128 WN4	NVλ4606-21 strong HeIIλ4686 weak P≃3d	HeIIλ4686,Δλ≃1 Å HeIλ4471 P≃3d	(binary)
132 WC6	CIIIλ4650 strong equiv. width variable P≃9d	CIIIλ4650,Δλ≃2 Å P≃9d	(binary)
134 WN6	HeIIλ4686 strong	HeIIλ4686,Δλ≃ 1 Å irregular	((binary))
135 WC8	----------	----------	no binary
137 WC7	CIIIλ4650 weak	----------	(((binary)))

(Continued) TABLE 1

138 WN5	HeIIλ4686 weak	----------	(((binary)))
139 WN5+06	HeIIλ4686 strong P≃4d	HeIIλ4686,Δλ≃ 5.5 Å NVλ4606,Δλ≃ 5.5 Å P≃4d	binary
140 WC7	CIIIλ4650 medium	$HeII\lambda4541_{abs}$,Δλ≃ 2 Å	((binary))

In the first column of Table 1 we list the number and spectral type of the star as given in the VI Catalog of Galactic WR Stars (Van der Hucht et al. 1981); in column two and three, a brief description of the variation of the profile and of the central wavelength of the lines is given; in column four we describe the probability of the star to be binary as follows: binary without parenthesis (probability of the star to be binary equal to 1): the stars in which both profile and radial velocity variations are strong and perfectly compatible with one period; binary in one parenthesis: the stars in which only one of the two variabilities can be compatible with a period; binary in two parenthesis: the stars in which variations of the profile are strong and similar to that of HD50896 but no obvious association with a period is possible; binary in three parenthesis: the stars in which the variations are weak and no coherent with a period; no binary: the stars in which no variations are visible.

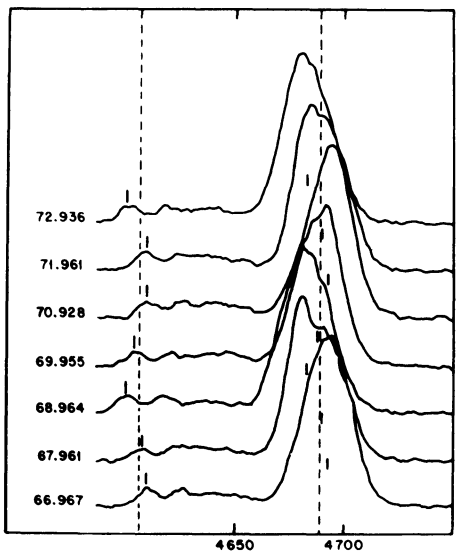

Fig. 1. 139, V444 Cyg: example of binary star. Note that profile and central wavelength variations are in phase.

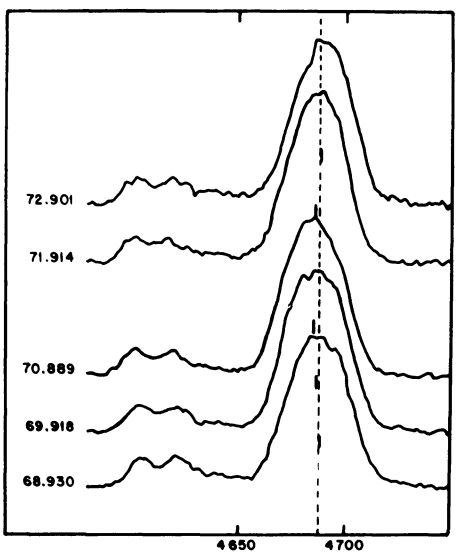

Fig. 2. 127, HD186943 example of (binary) star.

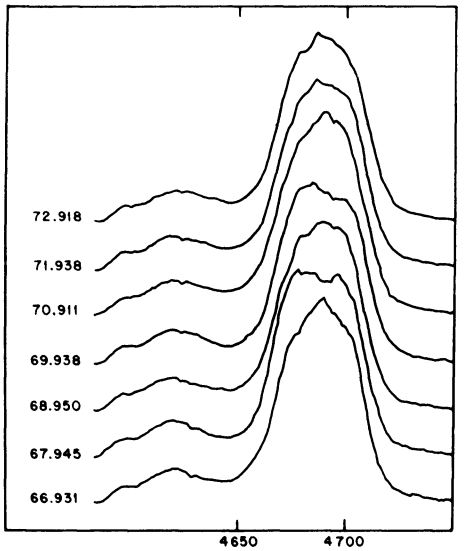

Fig. 3.134, HD191765, example of ((binary)) star.

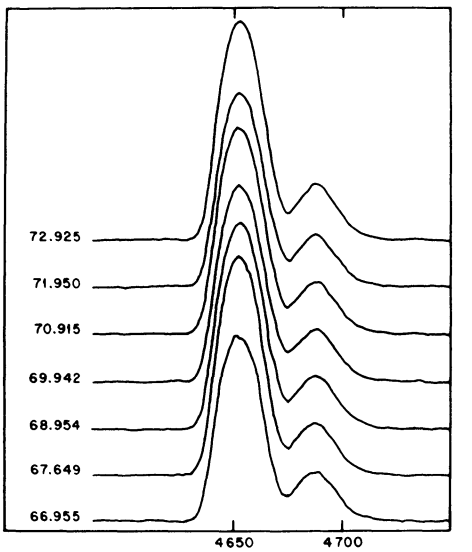

Fig. 4. 135, HD192103, example of no binary star.

Examples of the observational material used for this purpose are given in Figures 1 to 4. We present the spectra with the continuum normalized to 1 and in time sequence from bottom to top. The number at the left of each spectrum is the time of observation given as (JD-2,444,700). When useful, we present also in the figures the displacement of the central wavelength of the line and an arbitrary constant reference (dashed line).

Summarizing the results, in the total sample of 17 stars plus 5 well recognized binaries that belong to the same longitude interval the rate of WR showing strong evidences of variability (in Table 1, binaries with two parenthesis or less), probably connected with binarity, is 68%. For the WNE stars of the sample, the rate goes up to 100%; for the WNL the statistic is not significant; for the WC the rate of possible binary is 50%.

As conclusion we would emphazise that these are not definitive results but they show that the number of undetected binaries among the WR stars may be high at this moment and any conclusion starting from the actual ratio of binaries may be dangerous. A systematic work to find periodic variation of the profiles seems to be very important. A final remark: this work is based on the hypothesis that profile variations are evidence of binarity, this based on the fact that the known binaries do show regular profile variations, but in principle other mechanisms, as stellar rotation combined with inhomogeneities in the atmosphere, cannot be excluded as explanation of this phenomenon.

REFERENCES

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Van der Hucht, K.A., Conti, P.S., Lundström, I., and Stenholm, B. 1981, Space Science Reviews, 28, 227.