HD 50896: AN OTHER WR BINARY STAR

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The current ideas concerning the evolution of close binary systems (van den Heuvel, 1976), accepting the hypothesis that the system is not disrupted by the first supernova (SN) explosion, predict that the Wolf-Rayet phase can occur twice. The first time the companion of the WR star is a normal OB star and the second time it is a collapsed object. In this context, the importance of searching for binary systems with collapsed companions among the "single" WR stars is evident. Due to its large distance from the galactic plane, z = 280 pc (Smith, 1968a), when compared with the average height (z = 60 pc, Cruz-González et al., 1974) of extreme Population I stars, HD 50896 was considered to be a likely candidate to this type of system.

It is important to note that this star belongs to a complete sample of WN stars brighter than $v = 10^m$ and north of $\delta \sim -25°$. The statistical significance of the sample was suggested by Kuhi (1973). It contains seven binaries with OB companions and three supposedly single objects, two of which, HD 50896 and HD 192163, are associated with ring nebulae S 308 and NGC 6888, respectively. It is commonly believed that all WN stars associated with ring nebulae are single (Smith, 1968b). However, it must be noted that a ring nebula can be produced in a binary system by a spiral-in mass-loss mechanism, which could take place prior to the second WR phase.

In this framework, it would be very significant if HD 50896 were a binary system.

We have taken more than 100 spectra of this star in the wavelength range λλ4470-4800 A, with a very high signal-to-noise ratio, using the 1 meter telescope of the Tonantzintla Observatory and a SIT spectrophotometer. Figure 1 shows the spectra obtained from February to April 1977, and ordered according to a phase calculated with a period of 3.76 days. On this figure are indicated the phase, Julian Day - 2443000 for each spectrum, and the wavelength and identification of the more relevant features. The continuity of the profile variations of the NV blend at 4604-20 A and He II 4686 illustrates that the period is

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adequate. Upon including observations of October 1977 and February 1978, the periodical behavior as well as the period are confirmed.

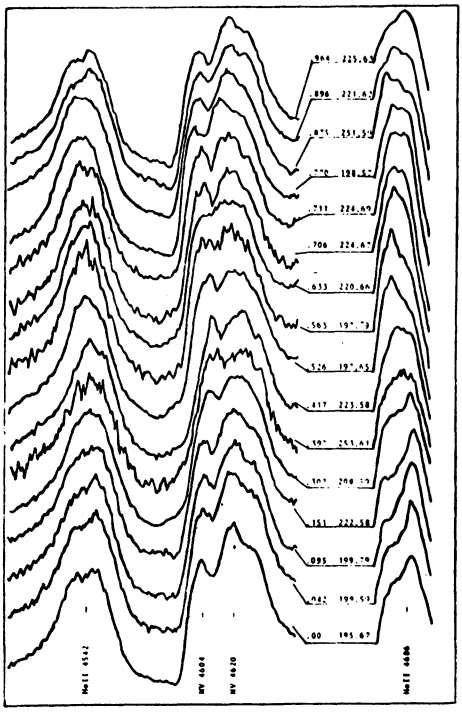

Figure 1. Spectra of HD 50896, the phase obtained with a period P = 3.76 days. Only the top of HeII 4686 is shown.

Differential photometry was made by E. de Lara and C.F. at the 1.5 meter telescope of the San Pedro Mártir Observatory from October 24 to November 7, 1977, with the 45 and 52 filters of the thirteen-color photometric system (Johnson and Mitchell 1975). The results ordered with the same phase used for the spectroscopic results are shown in Figure 2, and confirm the periodical nature of this star.

A 3.76-day period is too long to be compatible with radial pulsations (Stothers and Simon, 1970) and the periodical recurrence of similar spectral features over one year weakens a spot-rotation mechanism. Therefore, a binary nature for HD 50896 is strongly suggested.

The large line to continuum ratio, the absence of absorption lines and the small amplitude of the light curve favor a small-mass companion. Although there is a strong uncertainty due to the severe deformations in the varying profiles, the observations support radial velocity variations of about 1 A. This implies that the mass function is $\sim .1\ M_\odot$ and for $M_{WR} \sim 10\ M_\odot$ we obtain a mass for the companion between 2 and 4 $M_\odot$, depending on the inclination of the orbit (90° and 30°, respectively).

The large height above the galactic plane and the small mass of the companion support the idea that HD 50896 is a runaway and that the companion is probably a collapsar. This is, incidentally, also consistent with the energy involved in the variations of the He II line (10^{34} ergs s^{-1}). The absence of an X-ray source can be the result of the degradation of this radiation by the high density plasma of the WR wind, or the emission in the γ-ray region, which is plausible due to the high velocity of the material being accreted.

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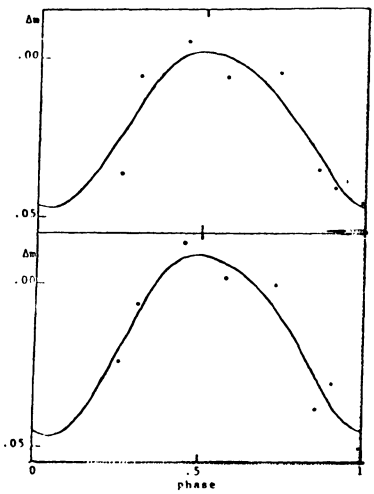

Figure 2. Differential photoelectric photometry of HD 50896 with the 45 and 52 filters. The phase is the same as in Fig. 1.

than in the second.

If we accept the hypothesis that HD 50896 is a WR + collapsar binary system, it remains to be explained why the number of these systems is so small compared to the WR + OB systems. The disruption of the binary system by the first SN explosion is an ad hoc explanation, and hence not attractive. We suggest that the explanation is related to the efficiency of the mass-loss mechanisms involved. That is, the first WR phase is a result of a Roche-lobe overflow mass-transfer mechanism, which is much more efficient than the spiral-in mechanism which produces the second WR stage. Therefore, because the He-core in both cases has presumably a similar life-time (Chiosi, private communication), the WR stage in its first occurrence lasts longer

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DISCUSSION FOLLOWING FIRMANI

Niemela: Which mass did you use for the WN star?

Firmani: 8-10 solar masses.

Snow: How did you determine the energy required to perturb the He II λ emission line?

Firmani: We calibrated our instrument, which has a linear response, by observing standard stars. We also adopted the absolute magnitude for HD 50896 determined by Morton.

Moffat: From my 1975 narrow band photoelectric observations (unpublished) of this star (HD 50896, WN5) on each of 37 continuous nights at La Silla, Chile, I found no clear evidence for a real variation above that expected ($\lesssim 0^m.01$) from the two constant comparison stars which were measured simultaneously. The filters used had band passes of ~ 100 Å centred on λλ ≃ 3635, 4680, 5640 the second of which is centred on the strong emission features of N III/V at λ ~ 4630 and He II at λ 4686.
(After returning home I plotted my photometric data in a 3.76 day phase diagram. The continuum shows a possible modulation with peak-to-peak amplitude of 0.008 mag. while the quantity m(4680)-m(5640) varies in antiphase with an amplitude of 0.012 mag. In addition, radial velocities os some lines on 12 Å/mm coudé plates taken in 1977 are compatible with a period of 3.76 days).

Morton: Over howmany periods did you observe the light variations?

Firmani: Three periods approximately.

Henrichs: Have you been able to determine the system velocity?

Firmani: No, we believe that the variations of the line profiles disguise the radial velocity effect.

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