THE WOLF-RAYET ECLIPSING BINARY HD 5980 IN THE SMALL MAGELLANIC CLOUD

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1. INTRODUCTION

The Wolf-Rayet star HD 5980, which is probably associated with the bright HII region NGC 346 of the Small Magellanic Cloud, was found to be an eclipsing binary by Hoffmann, Stift and Moffat (1978). Breysacher and Perrier (1980) determined the orbital period, $P=19.266\pm0.003$d, of the system whose light curve reveals a strongly eccentric orbit ($e=0.47$ for $i=80°$). The behaviour of the light curve outside the eclipses shows that we are dealing with a rather complex binary system. An analysis of the spectroscopic data is presented here.

2. OBSERVATIONS AND RESULTS

More than seventy spectra from two observatories are combined for the present study.
1)A series of 43 spectrograms (124 A°mm^{-1}) obtained during the period September 1975 - October 1978 by JB at the ESO 1.5m telescope on La Silla, Chile, with the "Echelec" spectrograph (Baranne and Duchesne, 1976) equipped with a Lallemand-Duchesne "caméra électronique".
2)A series of 28 spectrograms (45 A°mm^{-1}) obtained by AFJM, VSN and R. Mendez from December 1978 to January 1980, using the Carnegie image tube attached to the spectrograph on the 1m Yale telescope on Cerro Tololo, Chile.

C. W. H. de Loore and A. J. Willis (eds.), Wolf-Rayet Stars: Observations, Physics, Evolution, 317–320.

The resulting spectral classification for HD 5980 is WN4 + O7I:.
The radial velocity curves obtained for the λ4686 HeII emission line and for the H9 + λ4026 HeI absorption lines confirm the orbital period and the high eccentricity ($e=0.49\pm0.10$) of this binary system. Assuming that the λ4686 HeII line reflects the true motion of the WR component, one derives the following masses from the orbital elements:

$$M_{WR}\sin^3 i = 2.0 \pm 1.0\ M_\odot$$
$$M_O \sin^3 i = 2.2 \pm 1.1\ M_\odot$$

These values are extremely low considering the high luminosities of the stars. HD 5980 has indeed an absolute magnitude $M_v=-7.5$ (Azzopardi and Breysacher, 1979). Supposing that the K_{WR} value for HD 5980 has been reduced by perturbations we then adopt a mass ratio $M_{WR}/M_O = K_O/K'_{WR} = 0.3$, which is well in the range of the values determined for other WN4 binaries, where K'_{WR} is the true orbital semi-amplitude. The new values obtained are:

$$M'_{WR}\sin^3 i = 8\ M_\odot \quad ; \quad a'_{WR}\sin i = 76\ R_\odot$$
$$M'_O \sin^3 i = 27\ M_\odot \quad ; \quad a'_O \sin i = 23\ R_\odot$$

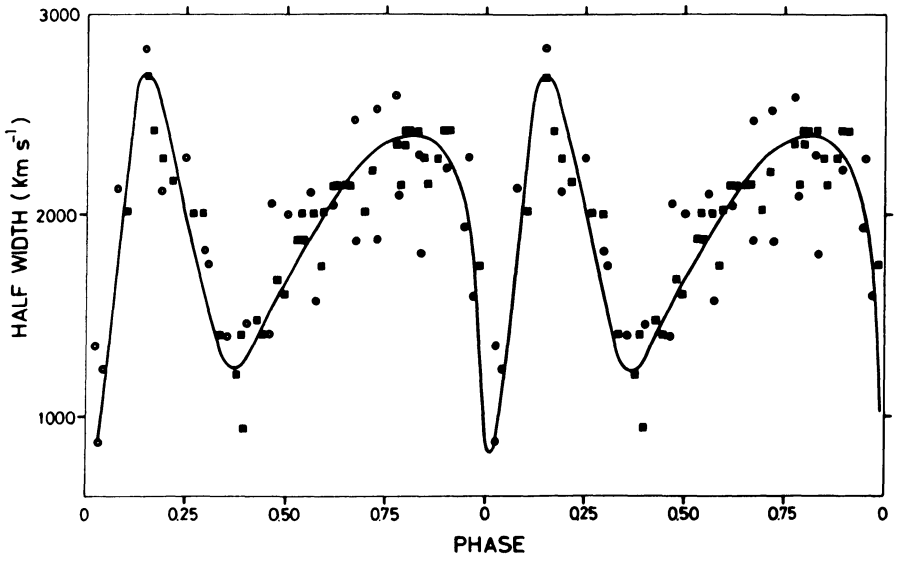

Figure 1. Full half width versus light curve phase for the emission line HeII 4686. The CTIO data (circles) refer to half density (~log intensity) width and have been adjusted to match the ESO data (squares) based on full widths at half intensity.

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The mass of the O-star now appears to be more realistic although it may still be somewhat low for its spectral type.

Figure 1 shows the phase-dependent variations of the total width at half height of the λ4686 HeII emission line.

3. DISCUSSION

Moffat and Seggewiss (1980) have noted that the eccentricity e is significantly different from zero only for WR binaries with relatively long periods (P≧50d). With P~19d, HD 5980 is thus the first moderately short period double-lined WR+O star binary to show a strongly eccentric orbit.

The λ4686 HeII radial velocity curve probably do not represent the true WR orbit and to understand why, the origin of the phase-dependent variations exhibited by this line deserves particular attention. Supposing that the λ4686 feature is the result of a combination of emission from the WR envelope as a whole, a hot localized region (brighter zone) in the WR envelope and the O-component wind (the existence of a strong stellar wind from the O-star is inferred from the radial velocity gradient of the Balmer lines), one can interpret the observed width variations in the following way.

- At light curve phase Ø=0, when the O-star is in front, part of the λ4686 emitting region remains visible, the brighter zone is fully eclipsed and only a narrow emission component is seen.
- Around periastron (Ø=0.17±0.04), due to the eccentricity of the orbit the interaction effect between the WR star and the O companion is strongest, the brighter zone is again visible and the λ4686 line reaches its maximum width.
- At the secondary minimum, Ø=0.36 (WR star in front), the brightened region of the WR envelope is not visible and again the λ4686 line gets narrower.

A multi-component λ4686 emission feature also explains nicely the reduced K_{WR} value one observes.

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DISCUSSION

Massey: The eclipses are equally deep, yet you have an O7I star and a WN4 star. Does this worry you ? Does the absolute strengths of the emission lines get weak at the correct phase ?

Moffat: The nearly equal eclipse depths of the light curve of HD 5980 are likely the result of the similar effective temperatures. The absorption lines are very weak and make detection of phase-dependent variations very difficult.

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