THE IRON CURTAIN OF THE WC 9 STAR HD 164270

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ABSTRACT

The emission lines in the optical and UV spectrum of the WC 9 star HD 164270 indicate a terminal velocity of its wind of $v_\infty \approx 1400$ km s^{-1}. In the UV spectrum Fe III absorption lines appear from transitions with metastable lower levels. Because they are displayed over only 830 km s^{-1}, it is suggested that they are formed in the decelerating part of the wind. A radius of 1.8 x 10^4 $R_\odot$ is found for the circumstellar Fe III shell. This value is within the range of radii calculated by Cohen et al. (1975) for the dust shells of WC 9 stars.

OBSERVATIONS

The WC 9 star HD 164270 (v = 9.01, d = 2.55 kpc) was observed with IUE at high resolution on 4 September 1978 (SWP 2855) and again on 15 March 1980 (SWP 8156). These two observations show identical spectral features. A few narrow absorption lines, although not as narrow as interstellar absorption lines, are seen superposed on the emission spectrum. Their line width is 0.3 Å and their line centers have central intensities of less than 10%.

Preliminary line identification by Conti and Van der Hucht (1979) was reconsidered and it was realized that identification with Fe III lines gives results which are more consistent.

ANALYSIS

The absorption lines measured at 1890.28, 1908.72 and 1920.97 Å are identified with the $a^7S - z^7P^o$ (UV 34) transitions of Fe III (Moore, 1952) and tabulated in Table 1. These transitions arise from a metastable lower level. The lines are Doppler shifted over -830 km s^{-1}. The P Cygni profiles of resonance lines in the same spectrum indicate a terminal velocity v_∞ = -1400 km s^{-1}. Therefore the Fe III spectrum originates either in the accelerating or in the decelerating part of

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Table 1. HD 164270 • WC 9 • Fe III (34) ABSORPTION LINES

λ_{obs} (Å)	IDENTIFICATION				W_λ (Å)	$\Delta\lambda$ (Å)	v_{rad} (km s^{-1})
	λ_{lab} (Å)	EP_1 (eV)	Mult. No.	log gf			
1890.28	1895.46	3.71	34	+0.48	880	5.18	820
1908.72	1914.06	3.71	34	+0.36	810	5.33	835
1920.97	1926.30	3.71	34	+0.21	800	5.33	830

the wind. Since no differences are found between two observations 517 days apart we may conclude that the Fe III shell is not a transient phenomenon, but that the Fe III shell originates in a fixed region in the stellar wind.

The lower level of UV 34 is metastable, enabling overpopulation of that level to occur in a low density environment. The analysis of the lines is analog to that by Bruhweiler et al. (1978) of Fe III lines in the spectrum of the Be star ϕ Per. We note that no Fe II lines are seen in HD 164270 with a velocity of -830 km s^{-1}. This implicates that Fe III is a dominant species and that it originates in a region with an electron temperature of at least 28 000 K. The fact that predominantly Fe III transitions from metastable lower levels are seen indicates that these lines are formed in a low density region of the wind. The a^5S state will be depopulated primarily by photo-excitation to higher levels.

A curve-of-growth analysis of the lines yields a column density of Fe III ions in the a^5S state of 6.5 x 10^{14} cm^{-2}. In deriving the ratio of the relative population of the metastable state a^7S to the ground state, we considered the levels a^5D, z^5P^o, a^5S, z^7S and e^7D. Since collisional processes in a low density medium can be neglected, the population ratios are determined by the statistical equilibrium equations, the Einstein coefficients, and the radiation field at 1125 Å (a^5D - z^5P^o), 2070 Å (a^5S - z^5P^o), 2428 Å (a^5S - z^7P^o), 1912 Å (a^7S - z^7P^o) and 1540 Å (z^7P^o - e^7D). The fluxes have been taken from Schmutz and Smith (1980). The ratio of the populations of the a^5S level and the groundlevel was determined to be 0.05. This value is independent of the dilution factor. The partition factor and the ionization equilibrium (House, 1964) were considered at 28 000 K. For the relative abundances in this WC star we used Y = 0.97 and Z = 0.03. A total mass column density of 2.04 x 10^{-3} g cm^{-2} was found for the shell. The column density and the measured velocity yield that

$$\frac{\dot{M}}{R_s/R_\odot} = 2.3 \times 10^{-9}\ M_\odot \cdot yr^{-1} \quad .$$

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Barlow et al. (1980) found that the average WC star has a mass loss rate $\dot{M} = 4.1 \times 10^{-5} \dot{M}_\odot$ yr^{-1}. Therefore we conclude that $R_s = 1.8 \times 10^4 R_\odot$ = 82 AU. Incidentally, this radius is of the order of magnitude of the radii calculated by Cohen et al. (1975) for the dust shells of WC 9 stars.

Particulars of our investigation will be published in the Astrophysical Journal.

LITERATURE

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DISCUSSION

DE LOORE: I have a question about the column density you used. You substract the hydrogen; however, then is should be replaced by helium! In my opinion this can represent a factor of $M \sim 3$.

Van der HUCHT: That is correct. The uncertainty in the radius of the dust envelopes (Cohen et al., 1975) is a factor of 10 at least. So the Fe III shell could still be coincident with the dust shell.

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