

VARIATIONS OF THE C III 5696 Å EMISSION LINE IN WOLF-RAYET STARS

J. D. SCHUMANN and W. SEGGEWISS

Observatorium Hoher List der Universitäts-Sternwarte, Bonn, F.R.G.

Abstract. Slow and rapid fluctuations of emission and absorption features of the C III emission line at $\lambda 5696 \text{ \AA}$ in WC stars are described. They might be attributed to moving clouds in the expanding stellar envelope.

The C III emission line at $\lambda 5696$ arising from the transition $3p^1P^0 - 3d^1D$ appears with considerable strength in all WC stars. The ratio of its intensity to that of the neighboring C IV doublet at $\lambda\lambda 5801/12$ increases from 0.3 for WC6 stars to 3.0 for WC9 stars (classification according to Smith (1968)). Selective mechanisms for the excitation of the upper level $3d^1D$ have been proposed earlier (Underhill, 1957; Gauzit, 1966) but have been ruled out as ineffective by Nussbaumer (1971). His calculations show that the occurrence of the line can be explained by taking into account effects of optical depth. The line profile changes from a round-topped one in spectra of WC9 stars to a flat-topped profile for the hotter types WC7 to WC5, whereas the profile of the C IV 5801/12 Å line is always round-topped.

Nine spectra of HD 152270 (WC6-7+O5) taken in 1971 by one of us (W.S.) with the Coudé spectrograph of the 152-cm telescope of the European Southern Observatory at La Silla, Chile, are shown between 5650 Å and 5900 Å in Figure 1 (original dispersion 12.3 \AA mm^{-1} on IIa-D) plates. The star is a spectroscopic binary with a period of 8.893 days (Struve, 1944; Seggewiss, 1974). The dates of mid-exposure of the spectrograms are separated by 1 day corresponding to roughly 0.11 in phase. The series of tracings shows the dramatic change of emission peaks and absorption components superimposed on the flat-topped profile of C III 5696 Å. The radial velocities of the most prominent short-wavelength and long-wavelength emission peaks are given in Table I; the peaks are marked in Figure 1. Table I gives in addition the velocities of the line center which are due to the binary motion of the star.

The slow variations stimulated a search for rapid variations of the top of the C III line. Since rapid fluctuations are often smeared out by an observational integration effect during long exposures one of us (J.D.S.) has obtained spectrograms with the television type image intensifier with SEC vidicon attached to the Cassegrain spectrograph of the 106-cm telescope of the Hoher List Observatory. The instrument combines high speed gain with linear response (Schumann, 1971), but has the disadvantage of low resolution power of 25 line pairs per mm. Three bright northern Wolf-Rayet stars were selected for short exposures: HD 192103 (WC8(+OB)), HD 192641 (WC7+Be) and HD 193793 (WC7p+O5). During two weeks in May/June 1974, 317 spectrograms were taken with exposure times of 20 to 30 s, normally spaced by two min. of vidicon preparation time. The spectrograms have been obtained as photographs

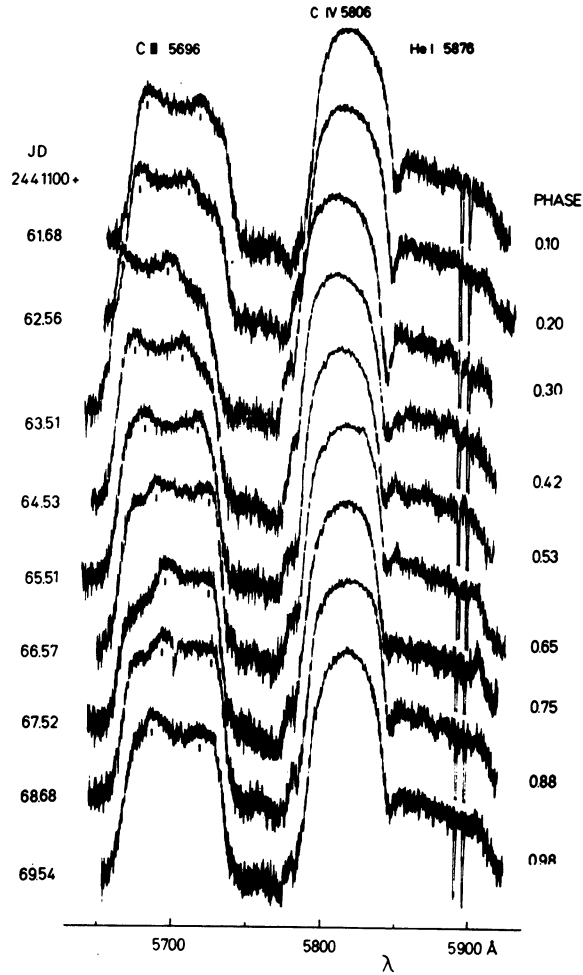


Fig. 1. Tracings of the spectra of HD 152270 obtained with the ESO Coude spectrograph.

TABLE I

Radial velocities of the center of the C III 5696 Å line and of short-wavelength and long-wavelength emission peaks superimposed on its flat-topped profile

Plate	JD 2441100+	Phase	Radial velocity		
			Center	Short	Long
			km s ⁻¹	km s ⁻¹	km s ⁻¹
G 2113	61.681	0.096	+ 80	-1047	+ 806
G 2117	62.563	0.195	- 8	-1342	400
G 2121	63.514	0.302	-117	-1505	34
G 2129	64.530	0.417	-147	-1299	323
G 2137	65.510	0.527	-178	-1057	830
G 2147	66.565	0.645	-116	- 740	+1283
G 2153	67.524	0.753	- 39	- 281	1316
G 2163	68.681	0.883	+ 46	- 380	1387
G 2167	69.535	0.979	83	- 785	963

directly from the television screen as spectra or from the oscilloscope screen as intensity tracings.

Several series of consecutive spectra show distinct spectral features shifting in wavelength on top of the C III line. One set of observations of the C III line in the spectrum of HD 193793 is reproduced in Figure 2. The dates of mid-exposure T starting with the uppermost tracing are indicated at the margin. The grid of the oscilloscope screen can be seen on most tracings as indentations at the left and right of the line top and can serve as wavelength marks.

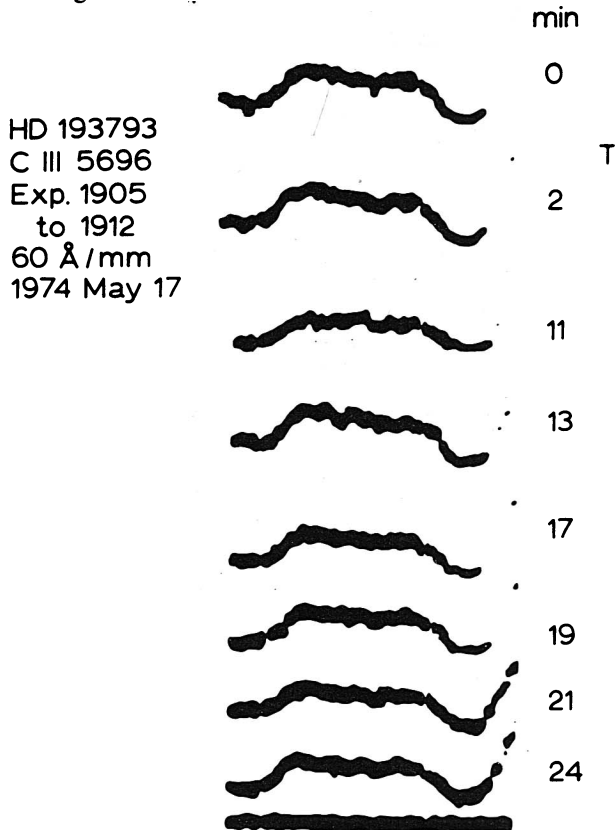


Fig. 2. Oscillograms of the spectrum of HD 193793 obtained with the SEC vidicon of the Hoher List Observatory.

A possible explanation of the emission and absorption features superimposed on the flat-topped line C III 5696 Å could be the occurrence of moving clouds or knots of higher density in the generally radially expanding atmosphere of the Wolf-Rayet stars.

Acknowledgements

We wish to thank the European Southern Observatory for the generous allocation of observing time. One of us (J.D.S.) was supported in part by grants from the Landes-

amt für Forschung des Landes Nordrhein-Westfalen and the Deutsche Forschungsgemeinschaft.

References

- Gauzit, J.: 1966, *Compt. Rend. Acad. Sci. Paris* **B262**, 1309.
Nussbaumer, H.: 1971, *Astrophys. J.* **170**, 93.
Schumann, J. D.: 1971, *Messtechnik* **79**, 174 and 189.
Seggewiss, W.: 1974, *Astron. Astrophys.* **31**, 211.
Smith, L. F.: 1968, *Monthly Notices Roy. Astron. Soc.* **138**, 109.
Struve, O.: 1944, *Astrophys. J.* **100**, 384.
Underhill, A. B.: 1957, *Astrophys. J.* **126**, 28.