

# EMISSION LINES IN HIGH RESOLUTION SPECTRA OF EXTREME HELIUM STARS

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ABSTRACT. The occurrence of emission lines in high resolution blue spectra of four extreme helium stars is reported. This phenomenon is most apparent in the case of BD-9°4395 which displays emissions in He I,  $\lambda$  3889 Å, C II,  $\lambda$  4267 Å and in the C II multiplet No. 1 ( $\lambda$  4740 Å). The latter is also present in LSE 78 and found to be variable. The C II emission lines are regarded as evidence for extended moving envelopes around BD-9°4395 and LSE 78. A possible relation to the hot R CrB star V348 Sgr is discussed.

HD 160641 and LSS 5121 show unidentified emission lines ( $\lambda$  4485.6 Å, 4504.0 Å) which are also observed in some Of stars. No emission lines were found in the blue spectra of 12 extreme helium stars.

## 1. INTRODUCTION

Peculiarities in the spectrum of an extreme helium star were first reported for BD-9°4395 (Kaufmann and Schönberner, 1977). The lines He I,  $\lambda$  3889 Å and C II,  $\lambda$  4267 Å appeared to be filled in by emissions. In the case of He I,  $\lambda$  3889 Å, the emission occurred at the central wavelength and seemed to be non-variable, while C II,  $\lambda$  4267 Å was suspected to be variable. The latter has been confirmed by recent observations (Jeffery et al., 1985) which revealed that the line occasionally occurs as a P Cygni profile. Jeffery et al. (1985) suggested that the general variability of C II,  $\lambda$  4267 Å indicates non-uniform mass loss which may derive from the underlying stellar pulsation (see also Jeffery, these proceedings). Since pulsational instabilities are observed in many extreme helium stars, it would be worthwhile to search for emission line features in other extreme helium stars.

Recently, high resolution spectra of all known (except one) extreme helium stars were obtained at La Silla using the ESO Gassegrain Echelle spectrograph (CASPEC) attached to a 3.6 m telescope (see also Heber, Jonas and Drilling; Drilling and Heber, both in these proceedings). These spectra covered the wavelength range from  $\sim$ 3850 Å

to  $\sim 4800 \text{ \AA}$  in most cases and careful examination revealed that five stars out of 17 showed emission lines. LSS 1922, which showed variable H  $\beta$  emission is a hydrogen-deficient binary and is discussed elsewhere (Morrison et al., these proceedings). The following extreme helium stars were found to have emission lines in their CASPEC spectra: BD-9°4395, LSE 78, HD 160641 and LSS 5121. The emission line spectra are described in detail in the next sections.

## 2. HELIUM AND CARBON EMISSION LINES IN BD-9°4395 AND LSE 78

### 2.1. BD-9°4395

One CASPEC spectrum of BD-9°4395 was obtained on April 9th, 1985. As already known from previous investigations (Kaufmann and Schönberner, 1977; Jeffery et al., 1985) emission line features can be observed in He I,  $\lambda 3889 \text{ \AA}$  and C II,  $\lambda 4267 \text{ \AA}$ . The former line has an unshifted central emission, while the emission component of C II,  $\lambda 4267 \text{ \AA}$  occurs in the blue wing (shifted by  $-58 \text{ km/s}$ ) of the (unshifted) absorption line (see Fig. 1). In previously published studies of spectra, the emission occurred either in the core or in the red wing of the underlying absorption line.

The high quality of the CASPEC spectrum allowed another peculiarity in BD-9°4395 to be detected: four spectral lines ( $\lambda\lambda 4735.46 \text{ \AA}$ ,  $4737.97 \text{ \AA}$ ,  $4744.77 \text{ \AA}$  and  $4747.28 \text{ \AA}$ ), which arise from the two electron transition  $2p^2 \text{ } ^2P - 3p \text{ } ^2P^\circ$  C II (Multiplet No. 1) occur in emission, as demonstrated in Figure 2 where the spectrum of BD-9°4395 is compared to that of BD+10°2179. The latter shows C II, multiplet No. 1, in absorption. Note that  $4735.46 \text{ \AA}$  is severely blended by an Ar II absorption line in both stars. The C II emission lines in BD-9°4395 are marked in Figure 2. They are shifted by  $-17 \text{ km/s}$  with respect to the absorption line spectrum (see Table I).

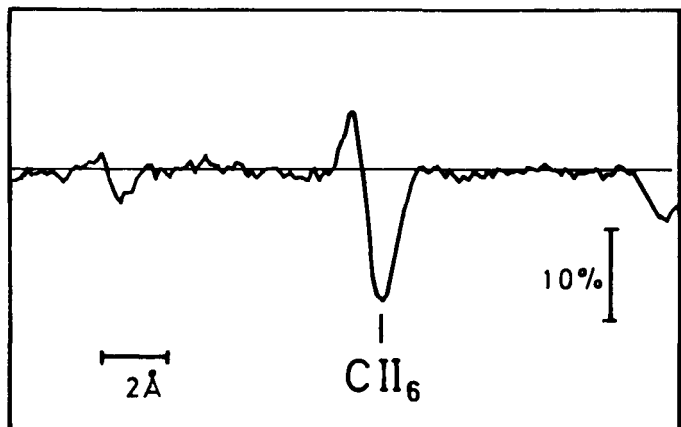


Fig. 1:

C II,  $\lambda 4267 \text{ \AA}$   
in the CASPEC  
spectrum of  
BD-9°4395. 10%  
continuum height  
is indicated by  
a vertical bar.

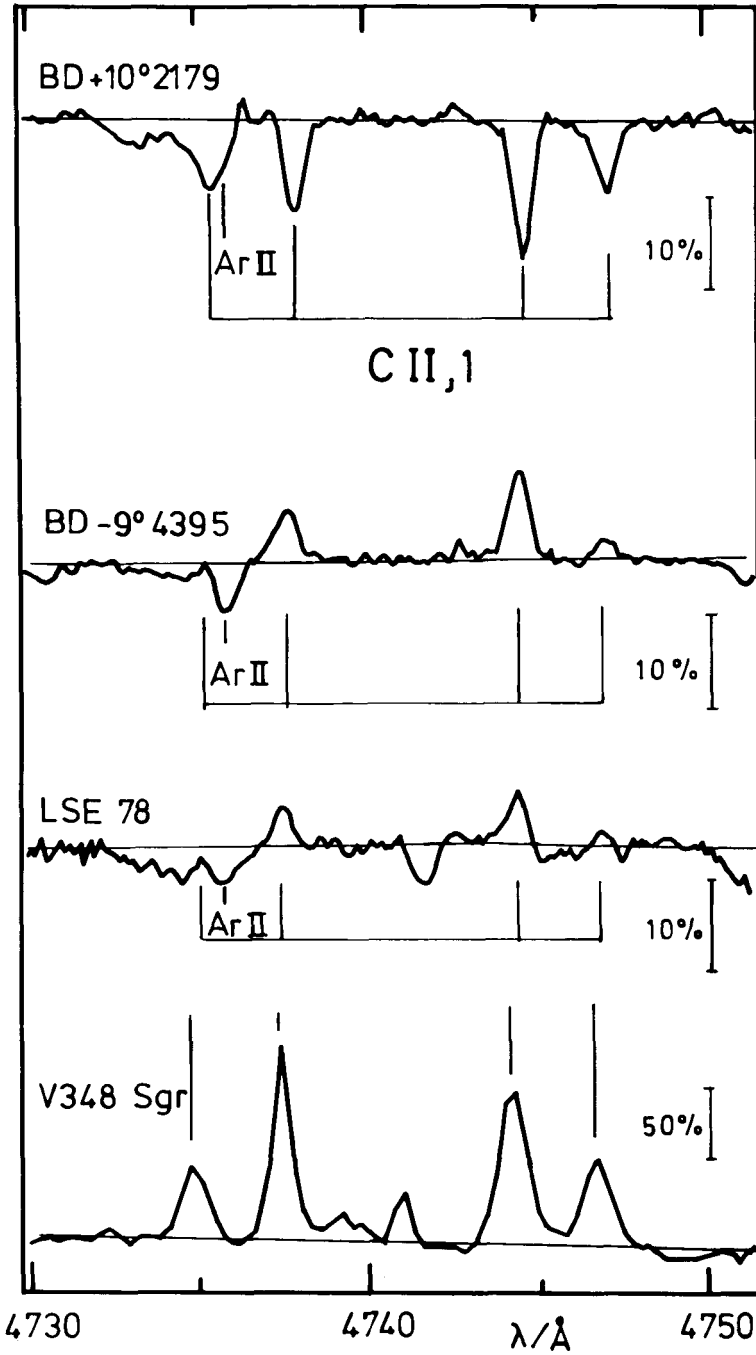


Fig. 2 C II, multiplet No. 1 in the CASPEC spectra of three extreme helium stars (BD+10°2179, BD-9°4395, LSE 78) and the hot R CrB-variable V348 Sgr (bottom).

## 2.2. LSE 78

Three CASPEC spectra of LSE 78 were obtained which revealed peculiarities in He I,  $\lambda$  3889 Å, C II,  $\lambda$  4267 Å and C II, multiplet No. 1 similar to BD-9°4395: He I,  $\lambda$  3889 Å is filled in by a central emission. C II, 4267 Å is unusually weak but, unlike BD-9°4395, did not show an emission component. C II, multiplet No. 1, is occasionally found in emission (see Fig. 2) and appears to be variable in strength: It is present in a spectrum obtained on April, 8, 1985, but was absent in a spectrum taken three days earlier. Radial velocities are given in Table I.

## 2.3. Discussion and comparison to V348 Sgr

The variable C II emission lines in the spectra of BD-9°4395 and LSE 78 can be regarded as evidence for an extended moving envelope around these stars and are probably formed by recombination at low envelope densities.

Since the extreme helium stars appear to be closely related to the R CrB stars, it would be worthwhile comparing the envelope spectra of BD-9°4395 and LSE 78 to the spectrum of a hot R CrB star. V348 Sgr is known to be such a star ( $T_{\text{eff}} \approx 20000$  K; Schönberner and Heber, these proceedings) with a carbon-rich envelope spectrum (Dahari and Osterbrock, 1984). Recently, Hunger (private communication) observed V348 Sgr with CASPEC when the star was faint ( $V \approx 15$ ). The spectrum covers approximately the same wavelength range as for BD-9°4395 and reveals emission lines superimposed on a weak stellar continuum. The carbon emission line spectrum consists of exactly the same lines as in BD-9°4395, namely C II,  $\lambda$  4267 Å and Multiplet No. 1. The latter is displayed in Figure 2. (Note that the plot scale for V348 Sgr differs from the others.) Radial velocities (see Table I) can be measured only for the emission lines since no photospheric absorption lines are visible. (The results are in good agreement with previous measurements of Dahari and Osterbrock, 1984, see Table I.) Houziaux (1968) observed V348 Sgr at maximum light ( $V=12$ ) with high spectral resolution and derived a radial velocity of 174 km/s from the absorption line

Table I. Heliocentric radial velocities (km/s)

star	date	C II emission lines		absorption lines
		4267Å	4740Å	
BD-9°4395	8 Apr. 85	-111	-73	-56
LSE 78	4 Oct. 84	-	-107	-90
LSE 78	8 Apr. 85	-	-117	-92
V348 Sgr	Oct. 85	158	135	--
V348 Sgr			140 <sup>a</sup>	174 <sup>b</sup>

<sup>a</sup>Dahari and Osterbrock (1984)<sup>b</sup>Houziaux (1968)

spectrum. As in the case of BD-9°4395 and LSE 78, the C II emission lines are blueshifted with respect to the absorption lines. Hence, the C II emission line spectra of BD-9°4395 of LSE 78 apparently are formed in an envelope under physical conditions similar to that of the envelope of V348 Sgr.

This strikingly similar envelope spectrum can be regarded as additional evidence for a link between R CrB stars and extreme helium stars.

### 3. UNIDENTIFIED EMISSION LINES IN HD 160641 AND LSS 5121

Emission features at  $\lambda = 4485.6 \text{ \AA}$  and  $\lambda = 4504.0 \text{ \AA}$  were found in two spectra of HD 160641 (taken on April 3rd, 1984 and April 9th, 1985, respectively) and were found to have the same strengths in both spectra. LSS 5121 showed an emission only at  $\lambda 4485.6 \text{ \AA}$ . A line at  $\lambda 4504.0 \text{ \AA}$  occurred in absorption. These lines could not be identified. Wolf (1963) described spectra of Of stars and reported unidentified emission lines at  $\lambda = 4485 \text{ \AA}$  and  $4503 \text{ \AA}$ , along with numerous emission lines of hydrogen, helium, nitrogen and silicon. Unlike in the Of stars, no other emission lines are present in HD 160641 and LSS 5121.

### REFERENCES

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## DISCUSSION

N.K. RAO: Regarding the inverse P-Cygni profiles that is observed in the spectrum of BD -9°4395 is that part of the expanding atmosphere or emission superposed on absorption line?

HEBER: The observed C II profile in BD -9°4395 appears to consist of an emission superimposed on photospheric absorption line. The emission probably arises from recombination at low envelope densities.