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A SPECTROGRAPHIC STUDY OF TWO Of STARS: HD163758 AND HD117797

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RESUMEN. Hemos llevado a cabo un estudio espectrográfico de dos estrellas del tipo Of: HD163758 y HD117797. Se midieron velocidades radiales y se estimaron las tasas de pérdida de masa por comparación de perfiles observados de Hα y HeIIλ4686 con los perfiles teóricos calculados por Klein y Castor (1978). La tasa de pérdida de masa para ambas estrellas resulta de $2\text{-}8.10^{-6}$ Mo/a. En el espectro de ambas estrellas se observan líneas de carbono relativamente fuertes, ademas de las líneas correspondientes a estrellas del tipo Of.

ABSTRACT. We have performed a spectrographic study of two Of type stars, namely HD163758 and HD117797. Radial velocities were measured and an estimate of the rates of mass loss was derived by comparison of the observed profiles of Hα and HeIIλ4686 with the theoretical ones calculated by Klein and Castor (1978). The mass loss rate for both stars is $2\text{-}8.10^{-6}$ Mo/y. Relatively strong C lines are observed in the spectra of both stars, in addition to the spectral lines corresponding to Of type stars.

Key words: LINE-PROFILE — STARS-MASS-LOSS -- STARS-OF

I. INTRODUCTION

HD163758 was catalogued by Roberts (1962) as a Wolf Rayet star (Nº 78 in his catalogue), but reclassified by Smith (1968) as an Of star. Walborn (1973) and also Leep (1978) agree with the Of classification of HD163758. Using the photometric data obtained by Smith (1968), a distance of 4.5kpc is derived for this star.

HD117797, immersed in the HII region RCW78, was classified as an O8f star by Crampton (1971), who also measured its UBV colours. The estimated distance of HD117797 is 4.4kpc.

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In this paper we report a radial velocity study of the lines in the spectra of HD163758 and HD117797. We find indications of strong stellar winds in the spectra of both stars. The observed velocity gradients for the hydrogen Balmer absorption lines show a similar behaviour for both stars and indicate that Hα , Hβ and Hγ absorptions are forming in accelerated regions of the stellar atmosphere.

We also estimate the rates of mass loss by comparison of the observed profiles of Hα and HeIIλ4686 with theoretical profiles calculated by Klein and Castor (1978).

The reduction of the observational data is explained in part II. The spectra are described in part III and the results of radial velocity measurements and mass loss rate determinations are detailed in parts IV and V respectively.

II.OBSERVATIONS AND DATA REDUCTIONS

Twentyfive spectrograms of the stars under study have been obtained with the Cassegrain spectrographs attached to the 0.91m and 1m (with image tube) telescopes (plates labeled A and E respectively) at the Cerro Tololo Inter-American Observatory, Chile; and with the Cassegrain spectrograph of the 1.52m reflector (plates labeled I)at the Córdoba Observatory, Argentina. In Table 1 the journal of observations and the photographic emulsions and reciprocal dispersions used are detailed.

TABLE 1. JOURNAL OF SPECTROSCOPIC OBSERVATIONS

PLATE	JD (2440000+)	EMULSION	DISPERSION (Å/mm)	SPECTRAL REGION (Å)	TELESCOPE
HD163758					
I7804	787.8	IIaO	42	3700-4900	1.5m CO
I7809	788.8	"	"	"	"
A2659	1914.6	"	45	"	0.9m CT
A4112	2475.8	IIIaJ	"	"	"
A4119	2477.8	"	"	"	"
A4124	2478.8	098-04	85	5100-7100	"
A4425	2878.9	IIIaJ	45	3700-4900	"
A4430	2879.8	IIaO	"	"	"
A4434	2880.8	"	"	"	"
A4445	2882.9	"	"	"	"
A4451	2883.9	IIIaJ	"	"	"
I8943	2970.8	IIaO	42	"	1.5m CO
I8949	2972.7	"	"	"	"
A4767	3364.7	IIIaJ	45	"	0.9m CT
E6637	6137.9	"	90	5100-7100	1.0m CT
E6642	6138.9	"	"	"	"
E6649	6139.9	"	"	"	"
E6654	6140.9	"	"	"	"
HD117797					
E4977	5125.7	IIIaJ	45	3700-4900	1.0m CT
E4981	5126.6	"	"	"	"
E4986	5127.6	"	"	"	"
E5556	5511.6	"	"	"	"
E5556	5511.6	"	90	5100-7100	"
E5563	5512.6	"	"	"	"
E5563	5512.6	"	45	3700-4900	"

CO: Córdoba Observatory, Argentina.
CT: Cerro Tololo Inter-American Observatory, Chile.

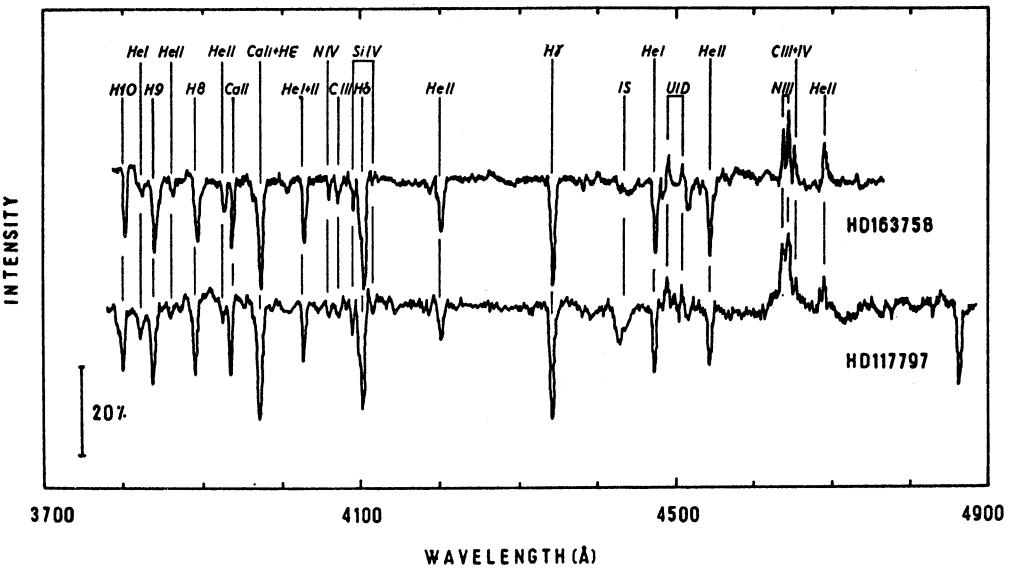

Fig. 1a. Average spectra of HD 163758 and HD 117797 indicating the identified lines in the blue region (3700-4900 A). IS: interstellar. UID: unidentified.

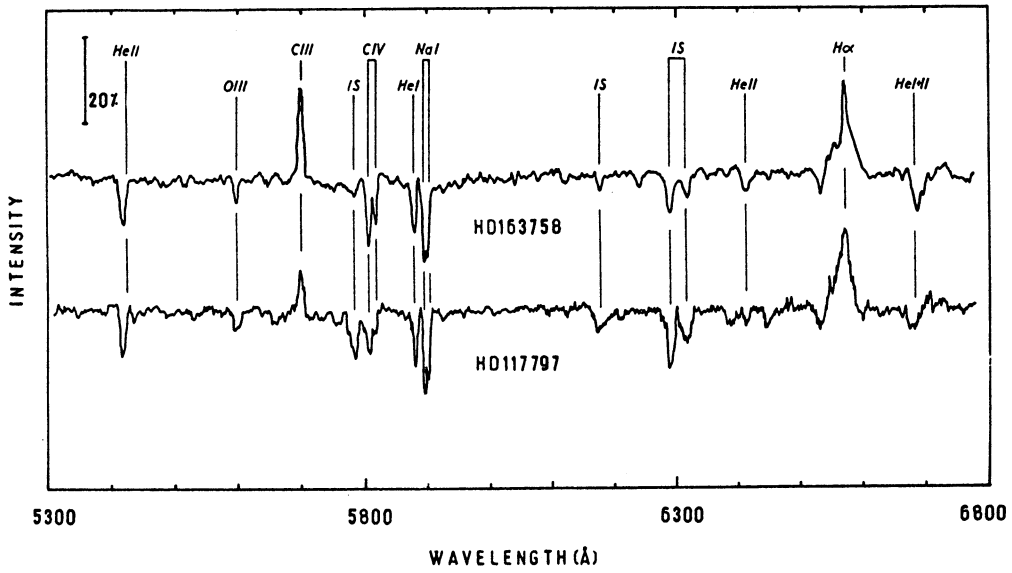

Fig. 1b. The same as Figure 1a in the red region (5300-6800 A).

The spectrograms were measured for the determination of the radial velocities with the Grant oscilloscope comparator-microphotometer at the Instituto de Astronomía y Física del Espacio (IAFE), Buenos Aires. Tables 2 and 3 resume the results of these measurements.

Also digitalized intensity tracings were made and averaged in order to reduce the plate noise. Figures 1a and 1b show the average tracing of the blue and red spectra respectively, where the principal lines are identified.

TABLE 2. HELIOCENTRIC RADIAL VELOCITIES (km s^{-1}) OF HD 163758

(a)Mean velocities

JD (2440000+)	ABSORPTIONS*	NIII4634-40 EM.
787.8	- 28	- 24
788.8	- 49	- 30
1914.6	- 23	- 45
2475.8	- 30	- 42
2477.8	- 37	-
2878.9	- 30	- 34
2879.8	- 48	- 46
2880.8	- 40	- 30
2882.9	- 39	- 46
2883.9	- 33	-
2970.8	- 49	- 51
2972.7	- 50	- 55
3364.7	- 48	- 42
MEAN VEL:	- 39	- 40
S.D. OF MEAN:	9	9

(b)Individual absorptions

ID.	LAMBDA(Å)	MEAN VELOCITY	S.D. OF MEAN	Nº OF PLATES
HI	3770.63	- 34	19	11
HI	3797.90	- 37	15	12
HI	3835.39	- 30	22	12
HI	3889.05	- 51	27	12
HI	3970.07	- 55	26	6
HI	4101.74	- 54	28	13
HI	4340.47	- 69	14	13
HI	4861.33	-116	33	5
HI	6562.82	-293	32	3
HeII	4199.87	- 43	12	13
HeII	4541.59	- 41	17	11
HeII	4685.68	-198	40	7
HeI	4026.19	- 70	16	12
HeI	4471.48	- 32	42	12
HeI	5875.62	- 84	18	5
SiIV	4088.85	- 78	29	11
SiIV	4116.10	-202	141	6
NIII	4097.31	- 51	41	9
NIV	4057.76	- 13	30	6
CIV	5801.33	- 50	19	5
CIV	5811.98	- 31	25	5

(c)Individual emissions

HI	6562.82	44	61	4
HeII	4685.68	- 43	22	10
NIII	4634.16	- 41	17	11
NIII	4640.64	- 40	16	11
CIII	5695.92	- 47	24	4

TABLE 3. HELIOCENTRIC RADIAL VELOCITIES (km s^{-1}) OF HD 117797

(a)Mean velocities

JD (2445000+)	ABSORPTIONS*	NIII4634-40 EM.
125.7	- 42	24
126.6	- 35	17
127.6	- 38	46
511.6	- 52	27
512.6	- 36	32
MEAN VEL:	- 41	29
S.D. OF MEAN:	6	10

(b)Individual absorptions

ID.	LAMBDA(Å)	MEAN VELOCITY	S.D. OF MEAN	Nº OF PLATES
HI	3770.63	- 36	8	5
HI	3797.90	- 30	18	5
HI	3835.39	- 33	21	5
HI	3889.05	- 36	13	5
HI	3970.07	- 16	9	2
HI	4101.74	- 17	10	5
HI	4340.47	- 45	17	5
HI	4861.33	- 80	48	5
HI	6562.82	-537	-	1
HeII	4199.87	- 28	14	5
HeII	4541.59	- 21	15	5
HeI	3819.61	- 32	16	4
HeI	4026.19	- 2	17	5
HeI	4471.48	- 29	7	5
HeI	5875.62	- 66	12	2
SiIV	4088.85	- 65	27	5
NIII	4097.31	- 11	6	3

(c)Individual emissions

HI	6562.82	124	8	2
HeII	4685.68	107	17	5
NIII	4634.16	32	17	5
NIII	4640.64	26	16	5
CIII	5695.92	- 23	7	2

* The selected absorptions are H11-8 and HeII$\lambda\lambda$4199,4541.

III. THE SPECTRA

As can be seen in Figure 1, the spectra of these stars show the typical features of the Of stars, namely the emissions of Hα, HeIIλ4686 and NIII$\lambda\lambda$4634,40. Other emission profiles are CIII+IV$\lambda\lambda$4647,50 and CIIIλ5696.

The Balmer lines appear in absorption (except Hα) and their profiles are quite symmetric.

We determined the spectral types of the stars under study by comparing the equivalent widths of HeIλ4471 and HeIIλ4541. According to the criteria of Conti and Alschuler (1971), the spectral type of HD163758 is O7If and that of HD117797 is O8.5If.

The strength of the carbon lines in these stars seems higher than in other Of stars. The equivalent width of CIIIλ5696 emission is 900mÅ in the spectrum of HD117797. Particularly, the equivalent width of the CIIIλ5696 emission of HD163758 (1400mÅ) is greater than that known for any other Of star (cf. tabulations of Conti 1974; Leparskas and Marlborough 1979), and the equivalent width of CIVλ5801 absorption (1200mÅ) is also greater than those of other Of stars. This suggests that HD163758 is a "carbon rich" Of star, as was also anticipated by Leep (1978).

The blue spectra (Fig. 1) also show for both stars P-Cygni profiles of the unidentified lines λλ4486,4502, which usually appear in emission for O supersiants later than O7. This is in correspondence with the appearance of CIIIλ5696 in emission, as was noted by Conti (1973).

IV. RADIAL VELOCITIES

A group of absorption lines for each star was chosen as representative of the motion of the photosphere in order to check for time variability of the respective stellar radial velocity (see tables 2 and 3). These lines are H11, H10, H9, H8 and HeIIλλ4199,4541 because their absorption profiles do not show influence of the expanding envelope.

For HD163758 we do not find radial velocity variations with amplitudes higher than 15 km/s. We repeated this analysis for the NIIIλλ4634,40 emissions obtaining an analogous result (cf. Table 2). We therefore conclude that HD163758 do not seem to be a spectroscopic binary, at least with a high amplitude radial velocity variation. Our results are in agreement with the velocities obtained by Leep (1978) using Coude plates.

From Table 3, HD117797 do not appear to have variable radial velocity either, but this is a preliminary result because the available plates are very few.

Figure 2 shows the Balmer progressions present in the spectra of these stars. For the sake of comparison we have also included in this figure the mean velocities of HeI and HeII absorptions and the mean velocities of NIII emissions.

Tables 2 and 3 also detail the velocities of individual lines in the spectra of HD163758 and HD117797.

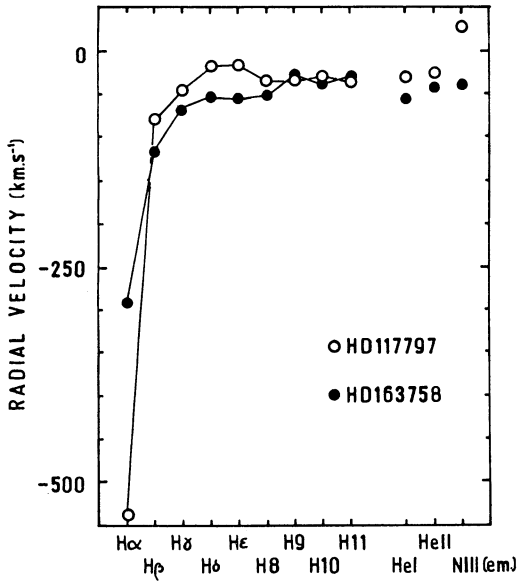

Fig. 2. Balmer absorption line velocity progression observed in HD163758 and HD117797. On the right side are shown the mean velocities of the absorptions of HeI, HeII and the mean velocities of the N III emissions.

V. MASS LOSS RATES

We have determined the mass loss rates by comparison of our observed emission line profiles of Hα and HeIIλ4686 with the line profiles for different mass loss rates calculated by Klein and Castor (1978). In Figure 3 we show the quality of the fittings for the Hα line. From this comparison we derive for both stars a mass loss rate

$$\dot{M} = 2\text{-}8.10^{-6} \ M_\odot/y$$

and a terminal velocity

$$v_\infty = 1600\text{-}1900 \ km/s \ .$$

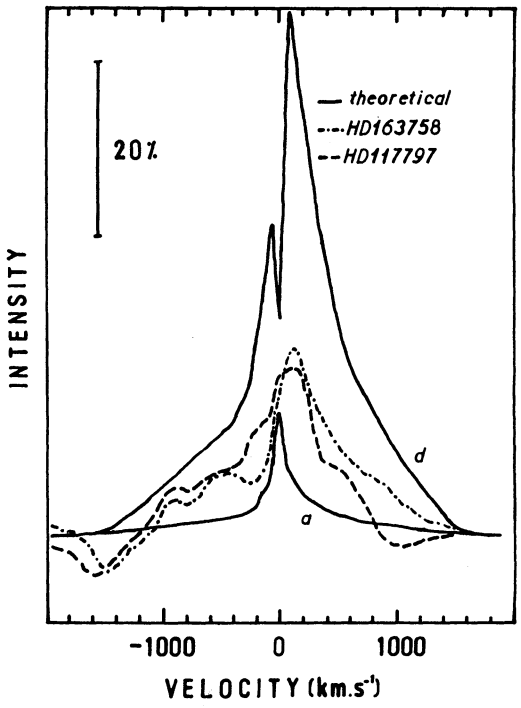

Fig. 3. Observed emission profiles of Hα in the spectra of HD163758 and HD117797 compared with models "a" and "d" of Klein and Castor (1978).

The limits correspond to models "a" and "d" respectively, of Klein and Castor (1978). The mass loss rate obtained is in agreement with those determined for other Of stars using observations of different spectral ranges (Garmany et al. 1981; Abbott et al. 1981; Lamers 1981). Moreover our estimate for HD163758 agrees with the value found by Garmany et al. (1981) from ultraviolet lines ($\dot{M} = 3\text{-}6.10^{-6}$ $M_\odot/y$).

For both stars, the terminal velocity is in agreement with the halfwidth of the Hα emission wings, indicating that Hα is forming along the whole accelerating region.

VI. CONCLUSIONS

The evolution theories which include mass loss effects (e.g. Maeder 1983) predict a diminishing of the C/N relation as a star evolves. From the

high mass loss rates found we would expect this to be the case for HD163758 and HD117797, but clearly from the presence of strong C lines in their spectra (cf. Fig. 1), their C/N values must be normal, if not higher than normal. These Of stars may be related to the group of ORC supergiants discussed by Walborn (1976).

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