STELLAR WINDS IN A-TYPE SUPERGIANTS

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1. INTRODUCTION

The contribution of A supergiant stars to the return of mass and energy to the interstellar medium is not very important. Abbott (1982) analised a sample of early stars and concluded that B and A supergiants provided less than 8 % of the mass input to the ISM by stellar winds. However, A-type supergiants are important in the framework of the stellar winds-mass loss phenomenology since they are located at the boundary between hot and cool stars, where radiative acceleration may not be sufficiently efficient to drive the wind.

We have studied the ultraviolet spectrum of all the A type supergiants observed with IUE (Talavera and Gomez de Castro 1987, 1988). This work allowed us to classify them in two groups. The *Group I* contains the less luminous A supergiants; these stars show indications of mass outflow only in the Mg II resonance lines where an absorption component of variable blueshift and intensity has been detected. The stars included in the *Group II* show strong evidence of wind and mass loss in the UV resonance lines of Mg II, C II, Si II and Fe II, and the terminal velocity of the wind derived from the Mg II lines is about 250 km/s; the most luminous A supergiants belong to this group.

There are also two important indicators of mass loss in the visible: a) emission : Hα, Hβ, He I 5876Å, and b) dependence of the radial velocity on the excitation potencial of the lines and/or regular progression of the radial velocity along the Balmer series (Hutchings 1970, Wolf 1983).

The only systematic study of Hα in A supergiants was made by Rosendhal (1970). He found an evolution of the emission in the line with the absolute magnitude of the stars. He found emission in Hα for magnitudes brighter than Mv=-6.8.

In 1988 we started an observing programme whose goal is the detailed analysis of the envelope of the A type supergiants. As a first step we have obtained high resolution profiles of lines formed at different depths in the atmosphere of the stars. These data will allow us to model the wind and the structure of the outer layers of these stars.

We present here the first results of this programme.

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2. OBSERVATIONS

We have selected our stars from the compilation of Humphreys (1978). Since most of them belong to OB associations, we have a good estimate of the distance and therefore of the absolute magnitude. Part of the stars we studied with IUE are included in this first sample which is listed in Table 1.

The observations have been done with the Isaac Newton Telescope (INT) of the Observatorio del Roque de los Muchachos in the Canary Islands and with the 2.2 m telescope of the Calar Alto Observatory in September and October 1988. At the INT we used the Intermediate Dispersion Spectrograph (IDS) equipped with a GEC CCD and in Calar Alto we used the Coude Spectrograph with an RCA CCD.

The spectral intervals we have selected correspond to the following lines: Ca II K line (3933Å), Mg II (4481Å), Hβ (4861Å), Na I and He I (5890Å) and Hα (6563Å). We have observed all these lines in most of the stars of the sample with a resolving power around 20000.

Table 1. Hα Observations of A-type Supergiants

STAR	Sp.T.	Mbol	Observations INT	CA	Profile	IUE
BD +60 51	A2 Ib	-5.01	27,29/Sep		AB	
HD 3283	A4 III	-5.07	27,29/Sep		AB	
HD 236995	A0 Ia	-5.08	27,28/Sep		AB	
HD 46300	A0 Ib	-5.18	26,28/Sep	20/Oct	AB	Group I
BD +60 2542	A2 Ib	-5.31	27,29/Sep		AB	
HD 4717	A0 Ib	-5.58	27,29/Sep		AB	
BD +61 153	A0 Ib	-5.58	27,29/Sep		AB	
HD 209900	A0 Ib-II	-5.68	27,29/Sep	23/Oct	AB	
HD 211971	A2 Ib	-5.71	27,29/Sep	23/Oct	EM	
HD 5776	A0 Ib	-5.88	27,29/Sep		AB	
HD 2928	A0 Iab	-5.88	27,29/Sep		AB	
HD 14535	A2 Ia	-6.51	27,29/Sep		PCyg	
HD 13744	A0 Iab	-6.78	26,28/Sep	23/Oct	EM	
HD 16778	A2 Ia	-6.81	27,29/Sep		EM	
HD 207260	A2 Iab	-6.91	27,29/Sep	23/Oct	EM	Group II
HD 20041	A0 Ia	-6.98	27,29/Sep	20/Oct	EM	
HD 13476	A3 Iab	-7.04	26,28/Sep	23/Oct	EM	
HD 3940	A1 Ia	-7.10	27,29/Sep	23/Oct	EM	
HD 212593	B9 Iab	-7.22	27,29/Sep	23/Oct	AB	
HD 14433	A1 Ia	-7.30	26,28/Sep	23/Oct	EM	Group II
HD 15316	A3 Iab	-7.44	27,29/Sep		EM	
HD 223960	A0 Ia	-7.48	27,29/Sep	23/Oct	Pec	Group II
HD 21389	A0 Iab	-7.48	26,28/Sep	20/Oct	Pec	Group II
HD 213470	A3 Ia...	-7.64	27,29/Sep	23/Oct	EM	
HD 14489	A2 Ia	-7.81	26,28/Sep		EM	Group II
HD 17378	A5 Ia	-7.89	26,28/Sep	20/Oct	EM	Group II
HD 210221	A3 Ib	-7.94	27,29/Sep	23/Oct	EM	
HD 12953	A1 Ia	-8.20	26,28/Sep	20/Oct	PCyg	Group II
HD 223385	A3 Ia	-8.44	27,29/Sep	23/Oct	PCyg	Group II
HD 197345	A2 Ia	-8.61	27,29/Sep		EM	Group II

Mbol and Spec. Type from Humphreys (1978); INT=Isaac Newton Telescope; CA=2.2m Calar Alto; all the observing dates are 1988.

3. PRELIMINARY RESULTS: Hα

3.1 Data reduction

The spectra have been extracted from the CCD frames after dark noise correction and flatfielding. The one dimensional spectra so obtained have been rebinned into a wavelength scale by using a polinomial fit to the positions provided by the thorium-argon lines of the comparison lamp.

The resolution measured in the comparison spectra is 0.25 Å(11 km/s at Hα) and 0.40 Å(18 km/s) in Calar Alto and the INT respectively. Both set of data have a signal to noise ratio ranging between 100 and 200.

All the spectra have been divided by a linear continuum placed by eye.

The data have been processed using the IHAP and MIDAS systems.

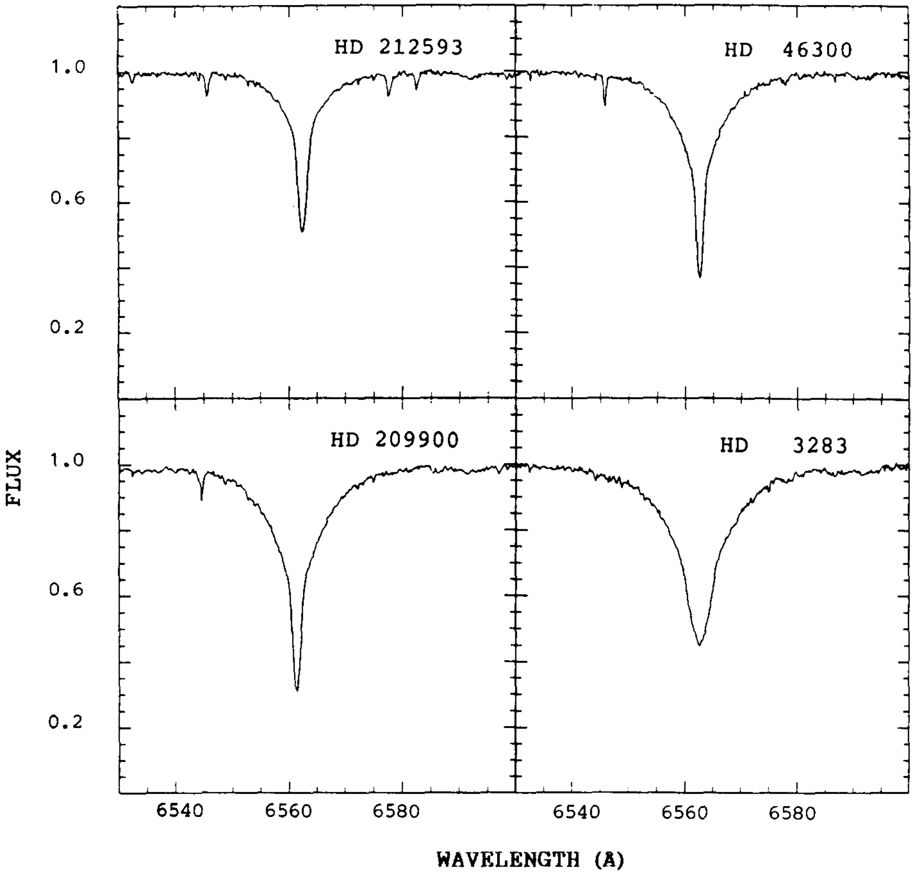

Fig.1. Hα profiles in some of the less luminous A supergiants.

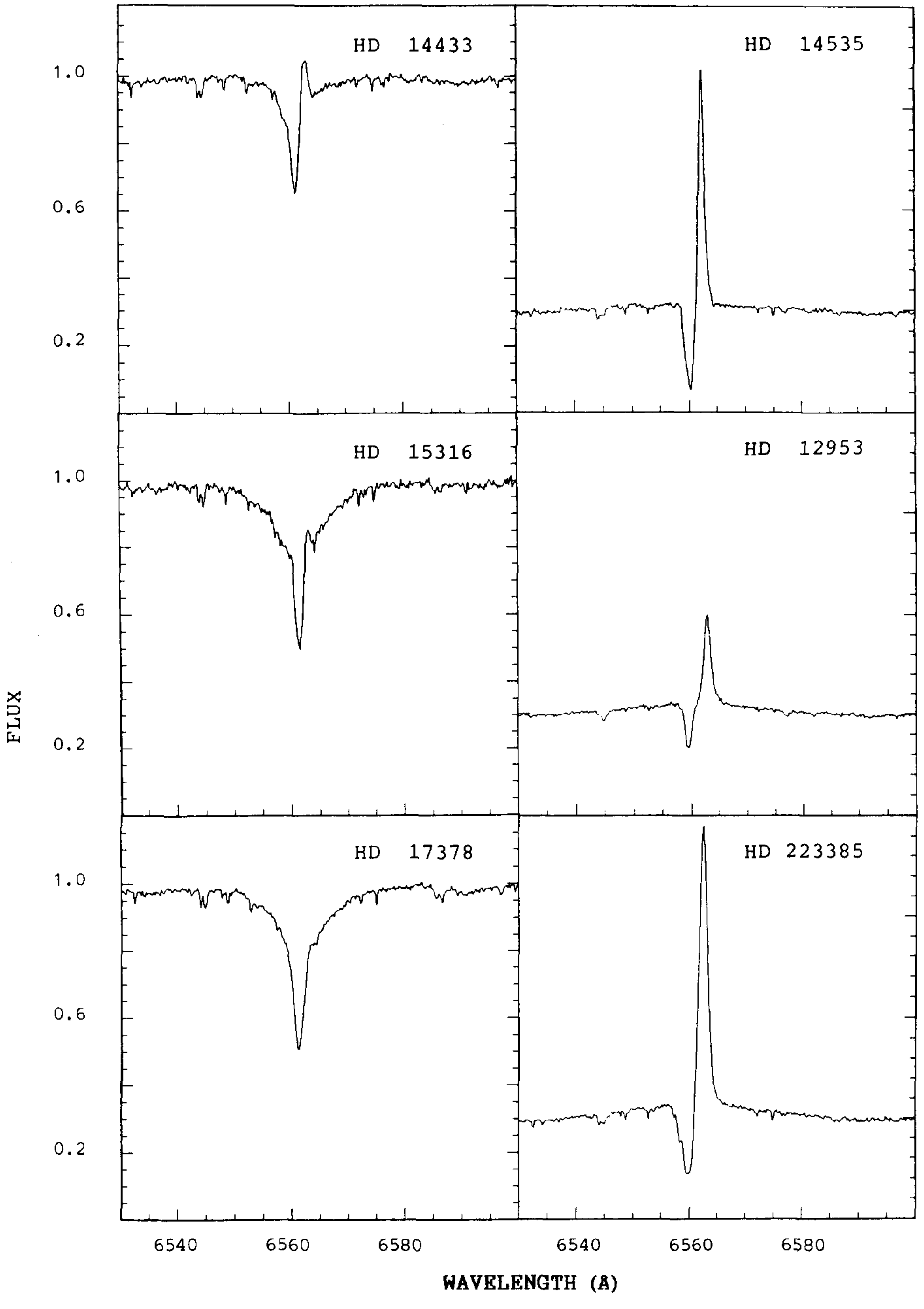

Fig.2. Evolution of the Hα line in luminous A supergiants.

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3.2 Observed profiles

The Hα profiles in A-type supergiants present very different shapes going from pure symmetric absorption to emission. The observed profile type is given for each star in Table 1. From that table it can be seen that the profiles evolve according to the absolute magnitude of the stars as it was noticed by Rosendhal (1970). This trend is ilustrated in Figs. 1 and 2. The less luminous stars show symmetric absorption profiles; then when luminosity increases an asymmetry starts developing in the core of the absorption which becomes a P Cyg type III profile for the brightest stars. In two "peculiar" stars the observed profile is in pure emission.

The less luminous stars do not show variability in the profiles, which have been observed for all the stars at least twice, at different epochs (see Table 1). However we have observed variations in some of the stars showing asymmetric-emission profiles. Some of these variations are very strong. They will be studied in future work.

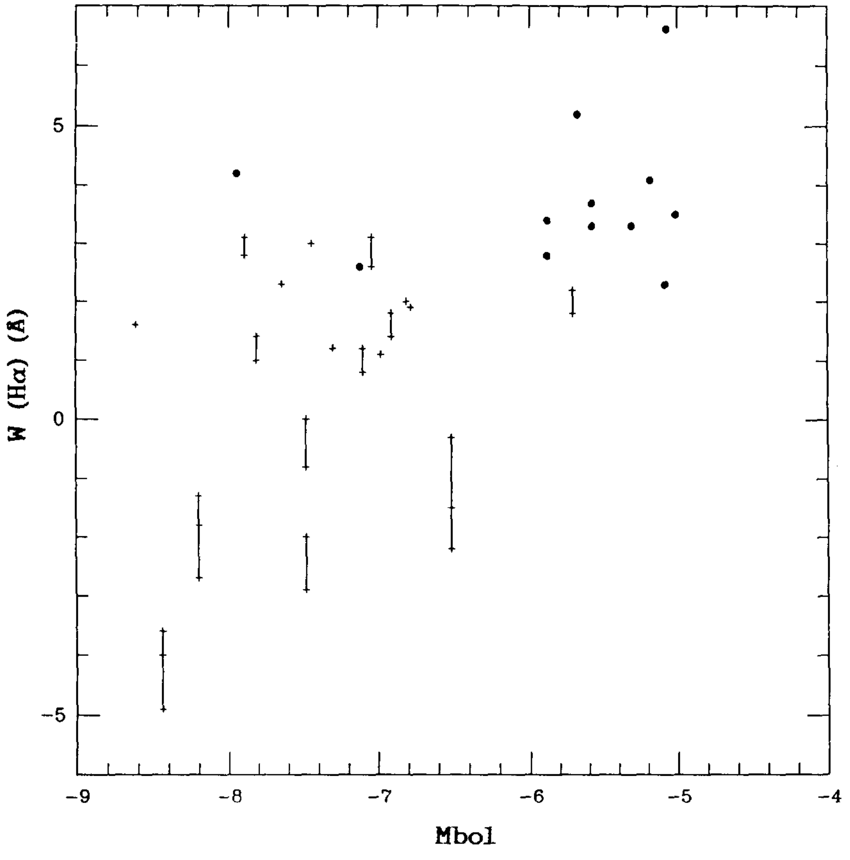

Fig.3. Equivalent width of Hα versus bolometric magnitude. Symmetric absorption lines are represented with dots and lines showing emission with crosses. Vertical lines indicate observed variation.

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3.3 Equivalent widths

We have measured the equivalent width of the observed Hα lines. The results are illustrated in Fig. 3, where we have represented W(Hα) against Mbol. The reported values correspond to absorption below the continuum minus emission above the continuum. In that figure we have indicated the variations observed in the equivalent width by vertical lines.

Although we cannot say there is a clear correlation W(Hα) - Mbol, it can be seen from Fig. 3 that there is a trend of increasing equivalent width with increasing magnitude. In other words the absorption in Hα is cancelled by emission in the core of the line when we go to more luminous stars. We have measured also the emission peak intensity for the stars showing that feature and we have obtained also the same trend.

From our sample of stars we can say that emission in the core of Hα is observed for stars brighter than Mv=-5.5.

3.4 Comparison with the U. V.

The sample of stars we have observed is larger than the one on which we based our studies with IUE. The first result of our new observations in Hα is the confirmaton of the division between Groups I and II established from IUE data. The less luminous A supergiants which showed weak signs of stellar wind in the U.V., those included in group I, have Hα in absorption, while the stars of group II, the most luminous ones, present emission signs in the Hα profiles.

4. CONCLUSIONS

We have presented some very preliminary results of a large programme intended to study the winds of A-type supergiants. Our data confirm and extend to a larger sample the results pointed out by Rosendhal (1970) and provide further evidence for the conclusions derived from our work in the U.V.

The project is in progress and we are continuing the analysis of the lines mentioned in Section 2. In the second part of our project we shall try the modelling of the envelope-wind complex in A-type supergiants.

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