DIFFERENTIAL LINE-SHIFTS

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In the beginning of this review, I paraphrase three statements from Paul W. Merrill (1960). (1) In the spectra of long-period variables, absorption lines of neutral metals show a shortward displacement increasing algebraically with excitation potential, probably due to atoms moving outward in the star's upper atmosphere with an expansion velocity of the order of 20 km s^{-1}. (2) About 6 weeks after maximum light emission components appear within the broad absorption at H and K of Ca II, but displaced about -100 km s^{-1}. A similar, but less extreme, behaviour is known for classical cepheids. (3) In quasi-constant red giants, the resonance lines of Ca II, Ca I, and SR II show circumstellar components displaced shortward relative to the normal stellar photospheric lines by a velocity which is correlated with the spectral type, typically -8 km s^{-1} for M6 II to -25 km s^{-1} for class M0 III.

From the very few specific citations in the literature, Table 1 lists examples of much larger shifts detected on high-dispersion spectrograms of extremely luminous stars. The stars named are somewhat fainter than any yet studied in detail in the far ultraviolet. Morton (1976) quotes a velocity of -2260 km s^{-1} for O VI λ1031 in the upper chromosphere of ζ Pup.

It is noticeable that, in addition to the progression by excitation potential, already discussed by Merrill and the cited authors of the recent papers on supergiants, there appears a progression with photospheric temperature among stars of the highest bolometric luminosities. Imhoff (1976) demonstrated among G, K, and M stars respectively, such a progression with luminosity class exists. For the profiles of Hα with "reverse P Cygni" emission, the trend to larger velocity displacements from the chromospheres of more luminous M stars is seen in Figure 1. Some of the displacements change with time; Smolinski et al. (1979) have noted an outburst from recent spectra of HD 217476 in which ions with lower excitation potential have velocities similar to Hα . *

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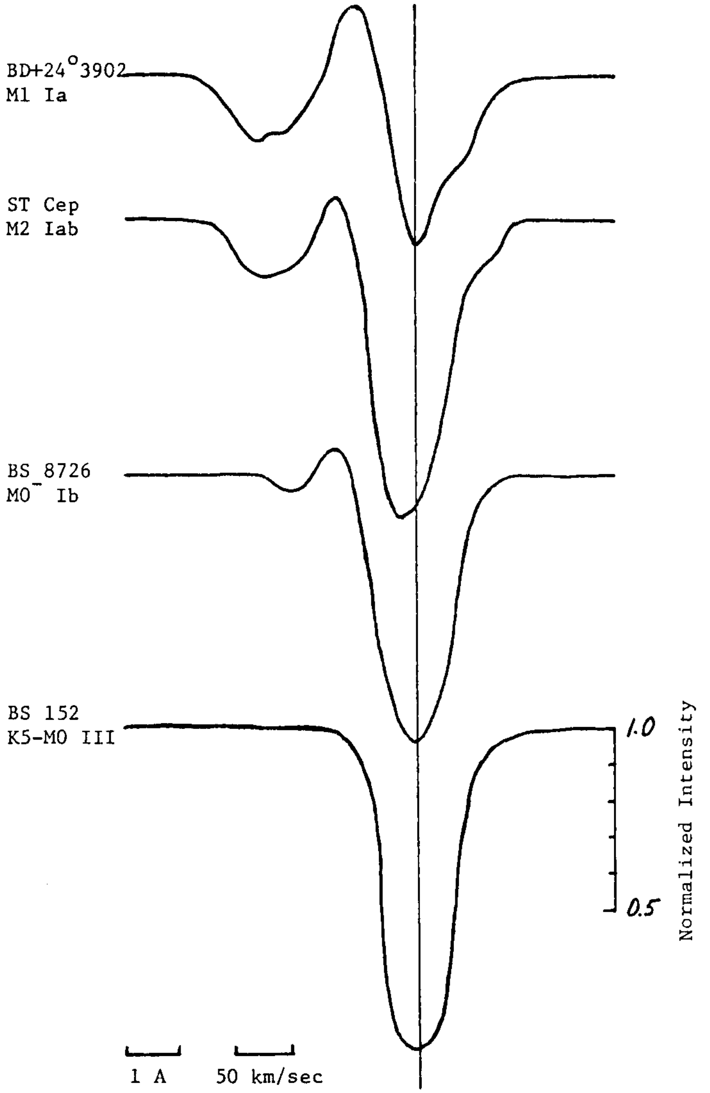

Fig. 1 Hα line profiles of early M stars of increasing luminosity. Uncorrected for instrumental profile. Vertical line marks rest wavelength of Hα . Wavelength increases to right.

(From Imhoff 1976)

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Table 1

HD Name	MK Type	ΔV	Ion	Fig.	Reference
206936 = μ Cep	M2 Ia	-52	Hα	1	Imhoff 1976
212466 = RW Cep	KO Ia-0	-71	Hα		"
217476 = V 509 Cas	G5 Ia-0	-81	Hα		"
163506 = V 441 Her	F2 Ia	-150:	Hα		Sargent 1969
223385 = 6 Cas	A3 Ia-0	-110	Hα		Aydin 1972
152236 = ζ^1 Sco	B1 Ia-0	-210	SiIV	2	Hutchings 1968
2905 = κ Cas	B0.7 Ia	-325	Hα		Rosendhal 1973
148937	O6 If	-340	Hα	3	Conti 1977

For supergiants of classes A and B, a progression with excitation potential has been discussed by several authors. Figure 2 summarizes the measures by Hutchings (1968) on the brightest member of the cluster NGC 6231. Conti (1977) has presented similar evidence for the Of star HD 148937 (see Figure 3).

It seems reasonable to suggest that the outward acceleration of matter escaping from stellar chromospheres is related to the age and possibly the mass of the star concerned. Each of the stars named in Table 1 has a bolometric luminosity of about two million suns.

I am indebted to R.E. Taam for the suggestion that this type of chromospheric activity may even be detectable as X-ray emission from very luminous stars.

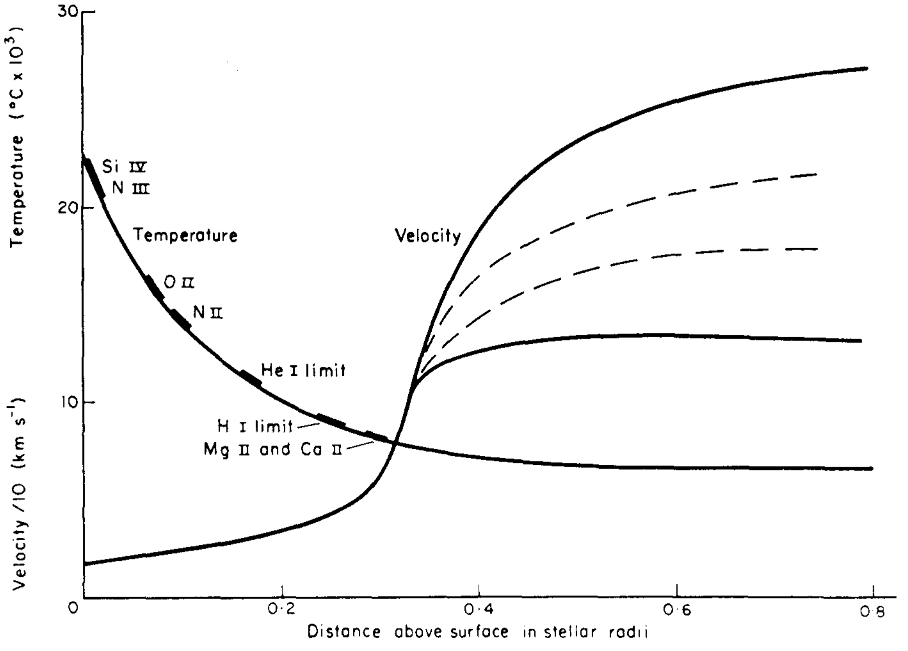

Fig. 2 Progression of velocity displacements for absorption lines in the spectrum of HD 152236 (ζ^1 Sco).

(From Hutchings 1968.)

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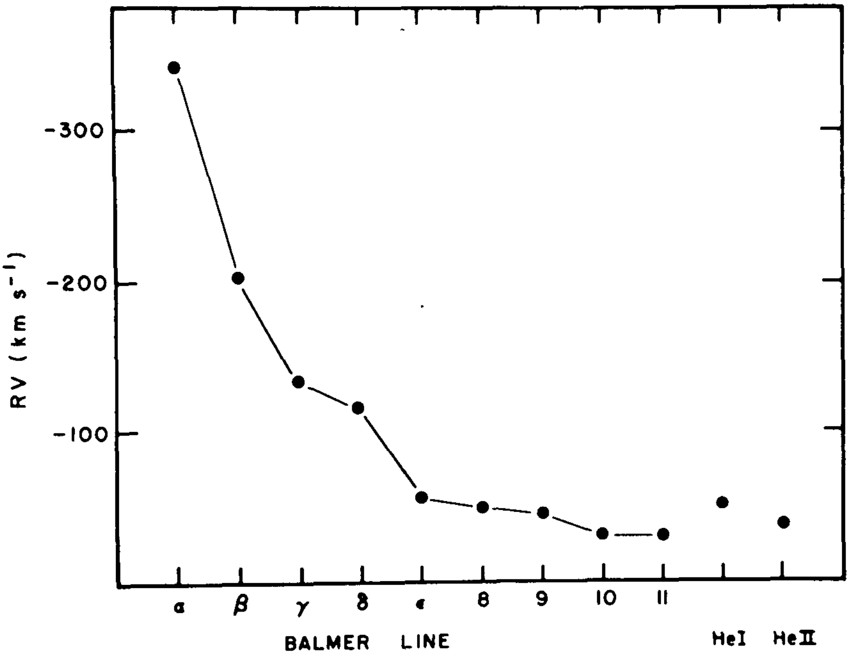

Fig. 3 Velocity progression of the Balmer, He I and He II absorption lines in the spectra of HD 148937.

(From Conti 1977.)

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