STATISTICAL PROPERTIES OF Be STARS

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Abstract. The emission features of 140 Be stars described in "An Atlas of Be stars" are briefly reviewed. The time scale of the emission variations are determined for about 35 stars. For several stars we estimated, on the Hβ line, the V/R ratio of the two emission components.

I. Emission features of Be stars.

Our sample contains 140 Be stars observed regularly from 1953 to 1976 at the Newton focus of the 120 cm telescope of the Haute Provence Observatory, see also. "An Atlas of Be stars" (Hubert-Delplace et Hubert, 1979). During the period 1953-1976, the emission lines of several stars are not always present, see table 1. The variability of emission, the shell features, and the percentage of stars which go from a "B star" to a "Be star" phase and both (notation B ⇄ Be) are given. The spectral classification of the stars was taken from Jaschek et al. (1980).

II. Time scale of "long term" variations of emission lines in some Be stars.

"Long term" variations of emission lines are often difficult to estimate because of a lack of continuous observations before 1950 except for some stars. Some results are given in table 2. P_0 gives an estimation of the B ⇄ Be cycle, and P_1 an estimation of the modulation of the emission during the "Be star" phase. In the case of stars with a "temporary B phase", the time scale of B ⇄ Be cycles seems larger for late Be type stars.

III. Time scale of the V/R variation in some Be stars.

The V/R ratio represents the variation of the V and R emission compo-

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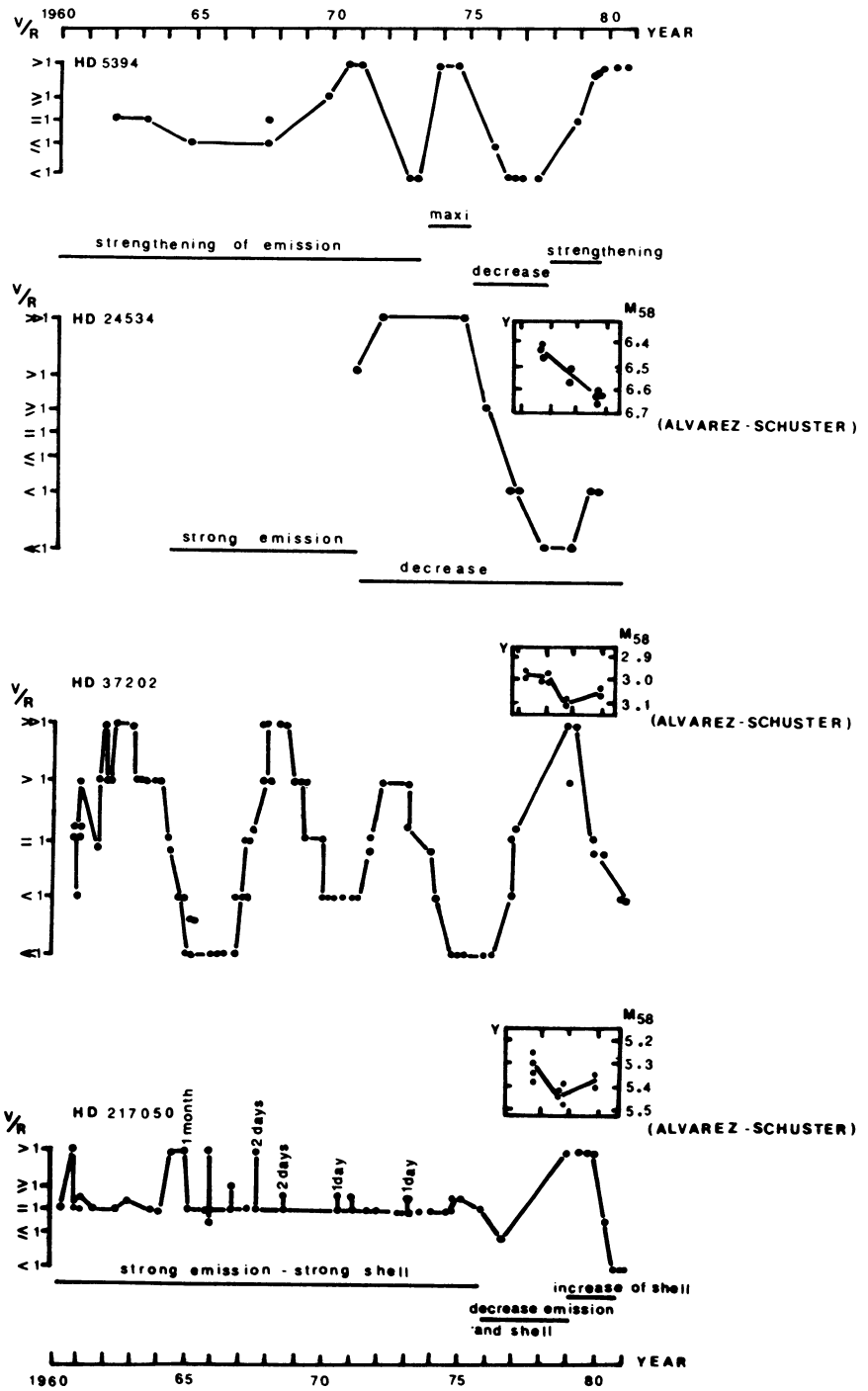

Fig 1. Some examples of V/R variations in Be stars.

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nents of the Hß line profile. For this determination we have used spectrograms obtained from 1960 to 1980 with the 193 and 152 cm telescopes (dispersion 9.67 and 12.27 A/mm respectively, Haute-Provence Observatory). We have searched some correlations between the V/R variation of the Hß line profile and the M_{58} variation given by Alvarez et Schuster (1981) ; some results are given table 3.

Table 1.- Generalities

	B0-B5e	B6-A0e
A) Permanent emission lines	70,5 %	77,5 %
B) Temporary emission lines	27,0 %	14,0 %
C) No emission lines	2,5 %	8,5 %

A) Permanent emission lines

	B0-B5e	B6-A0e
-strong H emission lines + Fe II emission lines (permanent or temporary)	74,0 %	4,5 %
-variability of emission :		
strong	27,0 % (77 %)	15,5 %
moderate	50,0 % (77 %)	29,0 %
no var.	23,0 %	55,0 %
-shell features (strong or weak , permanent or temporary)	51,0 %	29,0 %

B) Temporary emission lines

	B0-B5e	B6-A0e
-one change B → Be or Be → B	36,0 %	89,0 %
- 2 changes	63,0 %	11,0 %
-shell features during the Be phase	91,0 %	60,0 %

Table 2.- Time scale of variation of emission lines in some Be stars

A) Stars with a temporary " B phase "

star	sp.t	change	T.S.(years)	lifetime of B phase(years)
HD 35439	B1V	B⇆Be	P_0=8,12(var) P_1=3-4	2
HD 214168	B1V	Be⇆B	16-20	3
HD 33328	B2IV	B⇆Be	P_0∿8,12? P_1∿3-4	> 2
HD 177648	B2V	Be⇆B	∿ 10	∿ 2
HD 187811	B2V	Be⇆B	P_0∿11 P_1∿ 4?	3
HD 191610	B2IV-V	B→Be	> 27	> 6
HD 217543	B2V	Be→B	> 35	> 13
HD 168797	B3V	Be⇆B	P_0∿13-16 P_1∿ 4	7
HD 168957	B3V	B⇆Be	>20	∿ 8?
HD 189687	B3IV	B→Be	> 23	∿ 13
HD 197419	B3V	B⇆Be	P_0∿14 P_1∿ 3	5
HD 175863	B4V	B⇆Be	∿ 25	∿ 5
HD 201733	B4IV	Be B	> 26	4
HD 4180	B5III	B⇆Be	P_0 ∿17 P_1 ∿ 4	6
HD 171406	B5V	Be⇆B	13;6(var)	6;3
HD 171480	B6V	B⇆Be	P_0 ∿14 P_1 ∿ 5?	4
HD 6811	B7III	B→Be	> 32	> 10
HD 22780	B7V	B⇆Be	22<P<36	12<abs<24
HD 142926	B7-8V	B→Be	>40	14
HD 162732	B7V	Be=B	> 22	
HD 210129	B7V	B→Be	>50	
HD 175863	B8III	Be→B	>36	
HD 50658	B8III	B⇆Be	P_0 > 25 P_1 ∿16	
HD 164447	B8V	Be→B	>45	> 16
HD 23862	B8	Be	>75	31
HD 144	B9	B→Be	> 45	< 21

B) Stars always in emission

HD 178175	B2V	P∿10?(lack of observ.)	
HD 205060	B6V	P∿12-13	
HD 212076	B2V	P ∿ 8,var.	

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Table 3.- V/R variations of some Be stars

HD 5394 , γCas , B0.5	strong V/R var. during the emission var. Time scale ν4-6 years.
HD 24534 , χPer , 09.5V?	strong V/R var. during the emission decrease. Time scale ν 10 years? The V mag.(Ferrari-Toniolo et al. 1977)decreases when V/R decreases.M_{58}(Alvarez et Schuster ,1981) increases when V/R increases.
HD 28497 , 28GEri, B2V	strong V/R var. during the emission increase. Time scale ν ?-9 years.
HD 32991 ,105Tau , B2V	strong V/R var. in 1962-1980. Time scale ν 10 years.
HD 200120 ,59Cyg, B1V	V/R var. in 1972-1976(2 increases of emission respectively followed by 2 shell phases)and in 1980-1981.
HD 224544 , B6V	V/R var. during the decrease of emission.
HD 224559 , B4V	V/R var. during the decrease of emission. Time scale ν5-7 years.

Be stars with strong shell phases

HD 23862 ,Pléione, B8	weak V/R var. during the decrease of emission (Ylmaz ,1968). Large V/R var. in 1971-1976(strong decrease of emission in 1971-1972,then appearance of a shell phase) The V mag.(Golay,1979) and the B mag.(Sharov et Lyuty,1976) increases when V/R increases.
HD 37202 , ζTau , B2III	strong V/R var. Time scale: 7;4;7 years. Sometimes rapid changes in one day. In1977-1979 M_{58} increases when V/R increases (see Figure 1)
HD 142983 , 48Lib ,B3-4III	strong V/R var. Time scale:9→12 years.
HD 184279 , B0.5	strong V/R var. Time scale ν4 years .Very rapid changes in some days. In 1977-1979, M_{58} increases when V/R increases.
HD 217050 , EWLac ,B2III	V/R var. in 1976-1980 (see Figure 1)Sometimes very rapid changes.In 1977-1980 M_{58}increases when V/R increases. The same results are obtained with photometric data of Harmanec et al. (1980)

References

Alvarez, M., Schuster, W. : 1981, to be published in Revista Mexicana de Astronomia y Astrophysica.

Ferrari-Toniolo, M., Natali, G., Persi, P., Spada, G. : 1977, Astron. Astrophys. 61, 47.

Golay, M. : 1979, Publ. de l'Obs. Astr. de Strasbourg, 6, 101.

Harmanec, P., Horn, J., Koubsky, P., Zdárský, F.,Križ, S.,Pavlovski,K.: 1980, Bull. Astron. Inst. Czech. 31, 144.

Hubert-Delplace, A.M., Hubert, H. : 1979, An Atlas of Be stars.

Jaschek M., Hubert-Delplace, A.M., Hubert, H., Jaschek, C. : 1980, Astron. Astrophys. Suppl. Ser., 42, 103.

Sharov, A.S., Lyuty, V.M. : 1975 IAU Symposium N°70, p. 105.

Yilmaz,N.,:1968, thèse d'Université, Paris, unpublished

DISCUSSION

Divan: The uncertainties in the classification of Be stars due to the presence of spectral lines originating outside the photosphere can be quite large if low resolution spectra are used. But MK spectral types and luminosity classes deduced from spectra with a reasonable resolution are in very good agreement with the BCD classification, and the presence of Be stars of all luminosity classes from V to III is confirmed.

Marlborough: For the Be stars which change from Be to B or vice versa, is there any evidence to suggest that the spectral type is different when the emission lines are present to times when they are not? If there are changes in what way do they occur?

Hubert-Delplace: With the MK classification M. Jaschek does not find significant changes of spectral type when the Be stars change from Be to B and vice versa. But by using the Herman-Rojas classification based on H_γ, H_δ, H_ε photospheric lines (not disturbed by emission in general in the case of stars which present B⇄ Be cycles), an apparent change of spectral classification (3 or 4 classes) is observed. (see also Herman, IAU Symp. 50, 17, 1971).
According to Peton, Astron. Astrophys. 1981, in press, the minimum of the equivalent width $W\lambda$ (H_γ, $H\delta$, H_ε) gives the stellar spectral type and the maximum of this value gives the influence of the envelope as a screen effect. This was observed in 66 Oph by Rakotoarigimy and Herman, Coll. de Liège 1957 and in o And by Peton, Astron. Astrophys. 18, 106 at the beginning of the Be phase. In this case, the apparent luminosity class is III.

Harmanec: In a paper by Doazan, Harmanec, Koubsky, Kipata and Zdarsky (submitted to Astron. Astrophys.) we study the behaviour of 88 Her during the last 20 years. When the star became brighter and bluer and moved photometrically from B8IV-V to B6 IV-V, the H_α emission almost disappeared, metallic shell lines completely disappeared, H shell lines weakened and "photospheric" HeI lines also weakened, behaving thus like shell lines and indicating a shift to a later spectral type in a formally done spectral classification.

Hirata: In the case of Pleione, the weakening of the Balmer line wings occured when the brightness decreased. It cannot be explained by the veiling effect of the envelope, and suggests the variation in the photospheric level.

Endal: The luminosity classification is important in terms of evolutinary status of these stars. Does the luminosity class change when there is a Be→B transition.

Hubert-Delplace: We have used homogeneous data, spaced out over 23 years of observations at the Haute Provence observatory, to determine the time scale of the "long term" variations of Be stars, but we know

that these time scales are not periodic, and during the emission phase we have often observed secondary variations of emission which are easier to detect with higher dispersion.

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