Hα AND Hβ MEASURES AS RELATED TO Be STAR ROTATION

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Abstract. Photometric data for the hydrogen lines in 80 southern and 55 northern Be stars give evidence of a constant ratio for the emission in α and β in stars of similar spectral type. In an (α, β) diagram the intersection of this emission-line ratio with the standard relation for non-emission stars gives lower values than those corresponding to standard stars of the same spectral type. This may be due to rotational effects. A correlation of the variation in the β index with the V magnitude is also given.

Photometric observations of some 80 bright southern Be stars were obtained in the *UBV* system during a time interval of 12 yr (1963–1974). In a previous paper (Feinstein, 1975), it was shown that 19 of these 80 stars display changes in the V magnitude ($\Delta V > 0^m.15$). Some RI measures were also added.

In April 1970, February 1972 and December 1974, the Balmer lines Hα, Hβ and Hγ of the same stars were measured. (See Feinstein, 1974.) Previously, in December 1968, the Hβ line in 33 stars of the same group had been measured. Fifty-five northern hemisphere Be stars were also included in the same program during February and October 1970. The comparison of all these measures shows that a few

TABLE I

Be stars variable in β and in V
(difference: 1974 – 1968)

HD	$\Delta\beta$	ΔV
45 910	$+0^m.090$	$+0^m.05$
48 917	−0.002	−0.24
54 309	+0.222	+0.15
56 014	−0.029	+0.03
56 139	−0.046	+0.13
57 150	−0.127	−0.12
58 343	−0.019	−0.15
58 978	+0.024	+0.02
60 606	+0.047	+0.16
66 194	+0.132	+0.01
67 888	+0.123	−0.04
68 980	+0.114	−0.23
75 311	+0.086	0.00
88 661	+0.022	−0.10
131 492	−0.064*	+0.45*
148 184	–	−0.12
178 175	–	−0.17*
212 571	+0.108*	–

Notes: 131 492, $\Delta\beta$ (1972 – 1970), ΔV (1975 – 1968)
178 175, ΔV (1973 – 1968).
212 571, $\Delta\beta$ (1974 – 1970).

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stars display variations in the Balmer lines and those with significant changes in β ($\Delta\beta > 0\overset{m}{.}060$) are related to their variations in V (Table I). The differences in β and in V (obtained nearly simultaneously) for the observations between 1968 and 1974 are plotted in Figure 1, (ΔV, $\Delta\beta$) diagram. The position of the two stars, HD 54309 and 57150, which have the largest variation in β, indicates that a decrease or increase in V (greater or lesser brightness, respectively) is correlated with a decrease or increase in β (larger or smaller emission, respectively). All the other stars are distributed in a band which may be correlated in a different way. In conclusion, the (ΔV, $\Delta\beta$) diagram does not give a clear relation between both values.

It is not possible to find a similar correlation with the α index, since we did not measure it in 1968. However, if we compare the measures between 1970 and 1974, significant variations in the α index are shown by the stars HD 45910, 54309, 66194, 148184 and 212571. The sense of the variations is always the same as in the β index.

The (α, β) diagram for the standard stars is plotted in Figure 2. In Figure 3 a similar diagram for all the observed Be dwarf stars is given; it shows the influence of the emission in both spectral lines, since most of them have smaller values of α and β than the standard stars. To investigate their emission effects the same (α, β) array is plotted for separate groups of spectral types: O8–B1.5, B2, B2.5–B5, and B6–B8 (Figures 4 to 7). These four diagrams suggest that each group has a different α/β emission-line ratio. With the exception of the B2 stars, the low percentage of stars in each spectral type does not allow us to obtain a more precise relation.

The points where each emission-line ratio crosses the standard relation do not coincide with the corresponding $\bar{\beta}$ of each group of spectral types. Since the indices are smaller (column 6 of Table II), an effect due to the star's rotation may be apparent in α and β. The β values for stars with the break-up velocities were computed by means of the theoretical computations of Collins and Harrington (1966). This was

TABLE II

Emission-line relation for Be stars

	$\beta = a\alpha + b$			$\bar{\beta}$			
Sp. T.	a	b	β_i	(Crawford)	$\Delta\beta$	Sp. T.	$\delta\beta_R$
O8–B1.5	0.906	1.266	2.595	2.608	0.013		
B2	0.898	1.303	2.628	2.645	0.017	B2	0.015
B2.5–B5	0.607	1.740	2.634	2.678	0.044	B6	0.034
B6–B8	0.839	1.465	2.721	2.719	−0.002	B8	0.059

also applied for stars with smaller velocities, taking into account the random distribution in the inclinations. The difference of these two values, for three spectral types, multiplied by an appropriate coefficient (1.6), is tabulated in the last column of Table II. The differences are similar to those observed (column 6). The effects of binarity in β are smaller than $0\overset{m}{.}01$.

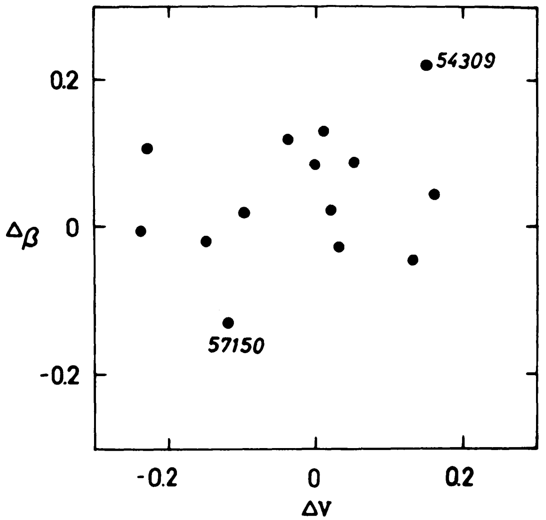

Fig. 1. The variation in ΔV vs the variation in $\Delta\beta$ from observations between 1974 and 1968. The two stars with large $\Delta\beta$ are indicated by their HD numbers.

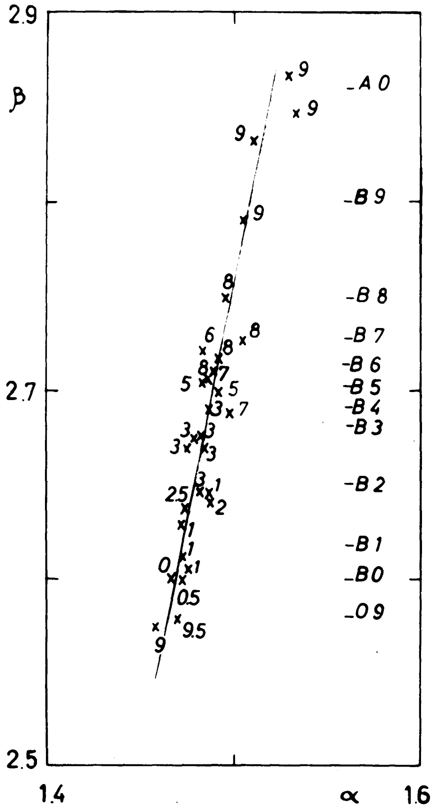

Fig. 2. The (α, β) diagram for the standard stars. The spectral types according to the calibration for β obtained by Crawford (1975) are given in the right margin.

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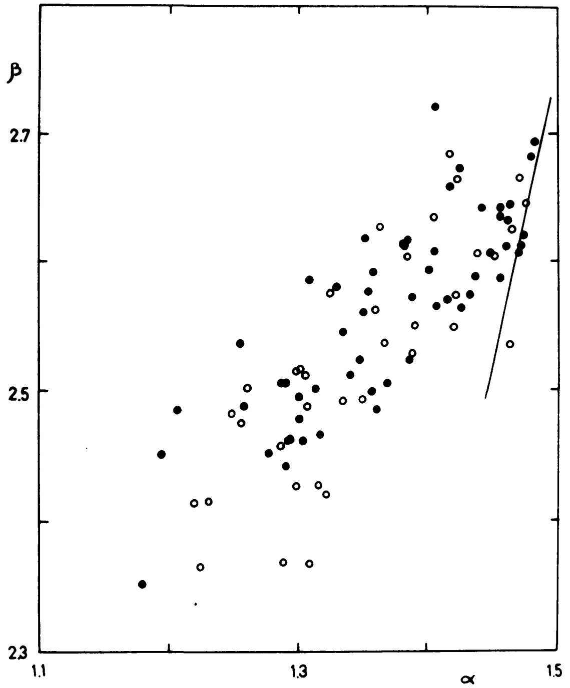

Fig. 3. The (α, β) diagram for all the Be stars. Open circles denote northern stars and dots southern stars. The position of the standard relation taken from Figure 2 is also shown.

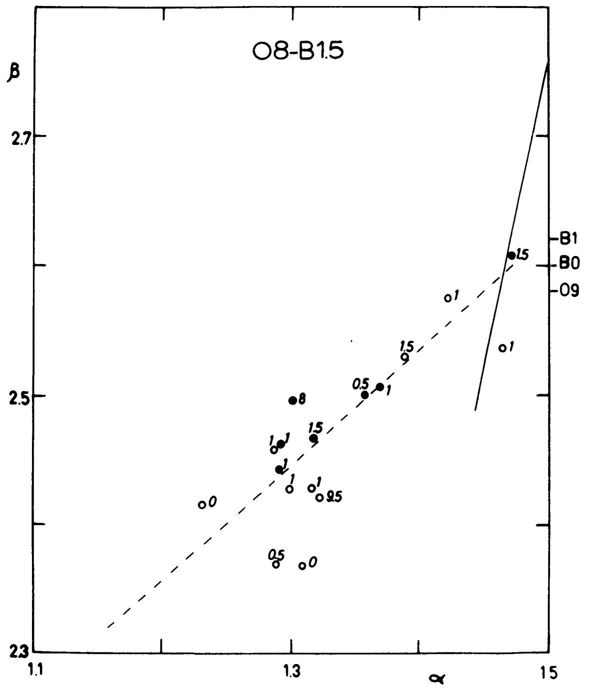

Fig. 4. The (α, β) diagram for the Be stars of spectral types O8–B1.5. The relation of the β values to the spectral types is given in the right margin. The standard relation (full line), and the weighted mean of the measured points (dashed line) are also indicated.

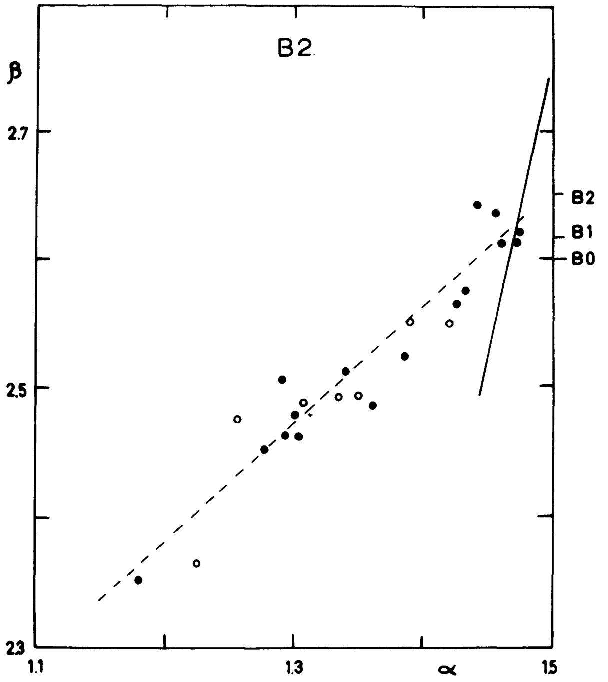

Fig. 5. The (α, β) diagram for the Be stars of spectral type B2. The meaning of the symbols is the same as in Figure 4.

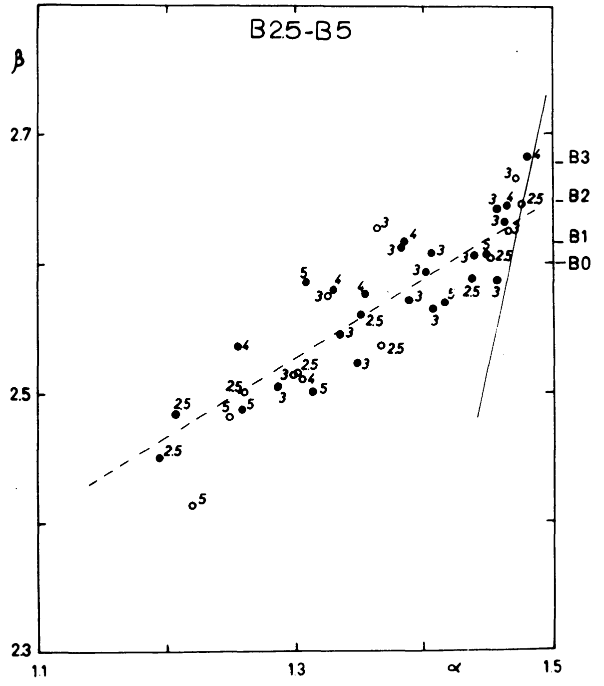

Fig. 6. The (α, β) diagram for the Be stars of spectral types B2.5–B5. The meaning of the symbols is the same as in Figure 4.

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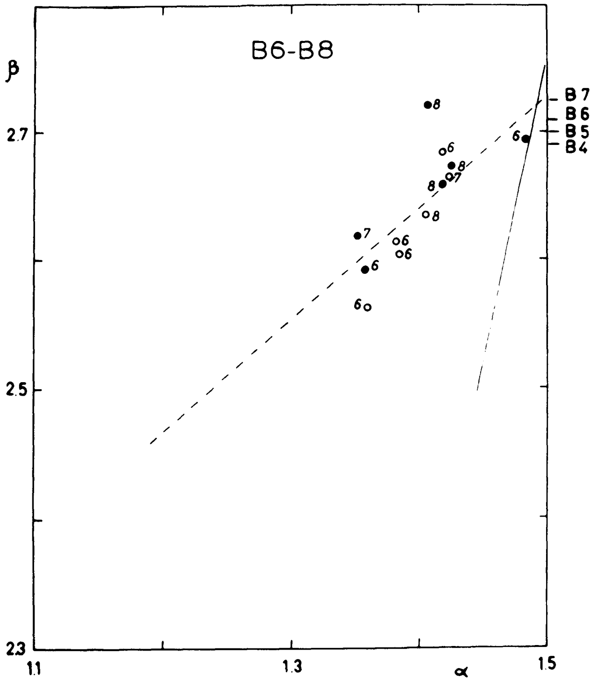

Fig. 7. The (α, β) diagram for the Be stars of spectral types B6–B8. The meaning of the symbols is the same as in Figure 4.

References

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DISCUSSION

Harmanec: What are the standard errors in your measurements?

Feinstein: For the standard stars, about 0.02 mag. in α and β, but for the Be's, I am not certain. Since we must extrapolate in the reductions of the measures, they may be larger.