LUMINOSITY CLASSIFICATION OF Be STARS BY BALMER LINE NARROW BAND PHOTOMETRY*

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Summary: The absolute luminosity of most Be stars can be determined by using Balmer line narrow band photometry with an accuracy of about 0.4 mag. The few cases in which this method fails can be detected.

It is well known that the Be stars can be easily discriminated from other stars with the help of at least two hydrogen line indices (Abt and Golson 1966).

In the course of a research program about the photoelectric determination of the absolute luminosities of OB stars, the H_α, H_β, H_γ lines of 65 Be stars were observed (Zeuge 1981). The filter system is somewhat different from e.g. the H_β standard system (Crawford and Mander 1966). The narrow filters are wider than usual (40, 35 and 25 Å for H_α, H_β and H_γ respectively). Therefore this system is more stable against effects like the rotational broadening of the lines.

In order to determine the emission of the Be stars, I applied techniques similar to those of Feinstein (1976). The non emission stars are located on a narrow straight band in the H_α - H_β H_α - H_γ diagrams:

$$H_\alpha = 0.741 + 0.558 \cdot H_\beta, \quad \text{(instrumental system)} \qquad (1)$$
$$H_\alpha = 0.757 + 0.537 \cdot H_\gamma.$$

Next I determined average indices for the spectral classes of those stars which do not show any emission and for which a complete MK classification is available. Now we can calculate the difference (E_α, E_β, E_γ) between the observed indices and the expected

* Based on observations obtained at the European Southern Observatory, La Silla

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indices in the case of no emission for those Be stars, which are included in the MK classification system.

The dependance of the emission E_β in H_β from E_α and E_γ from E_α respectively can be described very well by a quadratic expression where the linear term depends on H_β or H_γ:

$$E_\beta = 0.286 \cdot E_\alpha^2 + (1.501 - 0.80 \cdot H_\beta) \cdot E_\alpha ,$$
$$E_\gamma = 0.294 \cdot E_\alpha^2 + (1.204 - 0.63 \cdot H_\gamma) \cdot E_\alpha , \quad (2)$$

with s.d. 0.022 and 0.020 respectively (one star).

We now have two different possibilities to determine the emission in H_α by solving the equations (1) and (2) simultaneously, one from $H_\alpha - H_\beta$ and one from $H_\alpha - H_\gamma$. In general these two values coincide quite well (see fig. 1). Stars with differences greater than 0.015 mag are marked by an "X".

If the emission in H_α is known, the emission-free values H_{β_o} , H_{γ_o} can be calculated. In the following I shall use only H_{γ_o} because then the corrections are smaller.

22 of the Be stars are members of open clusters. For those I could calculate quite good absolute luminosities from the distances of the clusters. If one now applies the absolute luminosity calibration of no emission stars (Zeuge 1981) to Be stars using H_{γ_o}, then one sees that the luminosities of stars with strong emission are brighter than expected. The correction term is " $+ 1.10 \cdot E_\alpha$ " (E_α is negative). In this way we get the M_V calibration for Be stars:

$$M_V (\alpha\beta\gamma) = M_V (H_{\gamma_o}) + 1.10 \cdot E_\alpha . \quad (3)$$

This relation is valid if the two different values of E_α have nearly the same value. Fig. 2 shows the residues between this calibration and the absolute luminosities from the distances of the open clusters against E_α. " + " shows stars where the calibration is valid. The s.d. is 0.4 mag. " X " shows stars for which the calibration is not applicable because the results from the two calculations of E_α are too different.

In addition, some remarks about the percentage of the Be stars for which this method can be applied:
14 of 22 stars in open clusters are included in the calibration.
For all of the 43 field stars the method seems to be applicable, for all have small differences between the two ways of calculating E_α.

So, one might draw the conclusion:

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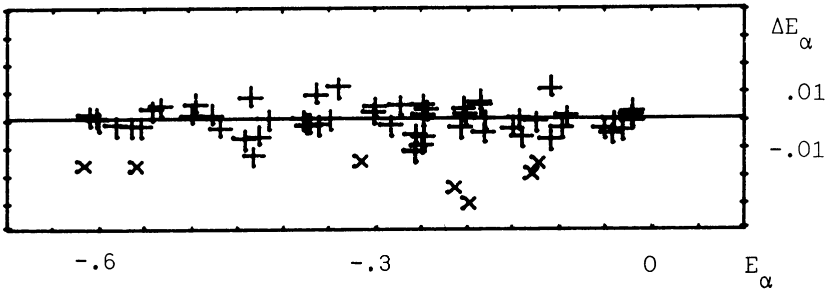

Fig. 1: The differences between the two ways of calculating E_α against E_α. " X " shows stars with $|\Delta E_\alpha| > 0.015$ mag.

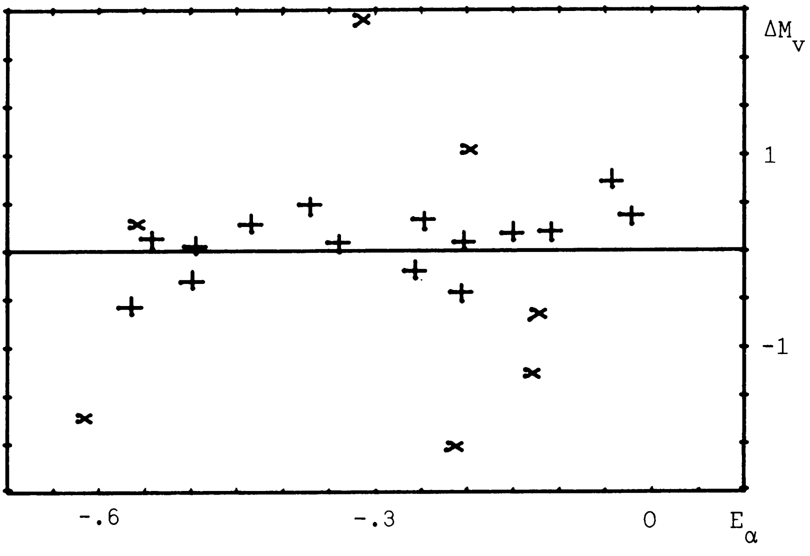

Fig. 2: The residues of the luminosity classification against E_α (see text)

The absolute luminosities of most of the Be field stars and of the majority of the Be cluster stars can be determined with an error of about 0.4 mag and the Be stars for which this method is not applicable can be recognized. It also seems that the photometric behavior of some of the cluster Be stars is significantly different from that of the field stars.

Literature:

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DISCUSSION following Kozok

Jerzykiewicz: 1. How does your $(U-B)_0$ correlate with the effective temperature?
2. For normal B stars your $M_V-(U-B)_0$ diagram would be a form of the HR diagram. Is it also the case for your last slide?

Kozok: 1. I do not know the effective temperature of these stars.
2. No, it is just an observational correlation of the photometrically derived absolute magnitudes and intrinsic colours $(U-B)_0$.

Slettebak: I still have a problem with the concept of "extreme Be stars", which have been defined in various ways. I hope that these objects will be discussed during this symposium so that we can decide whether such a physical group actually exists, or whether we are simply discussing various aspects of normal Be stars. My question is, how do you define "extreme Be stars"?

Kozok: I regard those stars as "extreme Be stars" which show a clear photometric excess. That means for fig. 1 that the stars which cannot be dereddened to the main sequence but are lying above are named by me as "extreme Be stars".

Harmanec: A note of warning: We obtained more or less systematic UBV photometry of CX Dra (HD174237) covering the period 1964-1980. If you plot the B-V and the U-B values in the U-B versus B-V diagram, they represent perfectly the cloud defined by your 150 stars.

Kozok: The stars have been measured on a time scale of one year and I have used for my analysis only stars which did not show any variation of more than $0\overset{m}{.}01$. Furthermore, the dispersion of the stars taken for line 2 is about $\pm\, 0\overset{m}{.}05$.

DISCUSSION following Zeuge

Harmanec: Is your relation fulfilled also by supergiant stars?

Zeuge: No, but these stars are seperated from the other Be stars on the $H\alpha$ - $H\gamma$ diagram.

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