A PRELIMINARY LUMINOSITY CALIBRATION OF THE uvby,β SYSTEMS FOR SUPERGIANT F-TYPE STARS

E. Antonello

Astronomical Observatory of Brera, Milano-Merate

1. INTRODUCTION

Calibrations of the uvby,β photometric systems have been made by Crawford (1975, 1978, 1979) for F, B and late A-type stars of luminosity class V-III; the calibration for early A-type stars has been made by Hilditch *et al.* (1983). One of the remaining areas of the HR diagram to be calibrated is that of the bright giant to supergiant region (luminosity class II-I). We have attempted to obtain a calibration in terms of luminosity for supergiant F-type stars. To this end we have used the statistical method of multiple stepwise regression analysis. Before doing the calibration for supergiants, we show the usefulness of this method by a comparison of the results obtained for dwarf F-type stars with the previous calibration given by Crawford (1975).

2. DWARF F-TYPE STARS

The multiple stepwise regression analysis is a method of the multivariate statistical analysis which allows us to correlate a dependent variable with a set of significant independent parameters selected from a larger set of variables (see e.g., Antonello 1983). We have used a program by Buzzi-Ferraris (1975) which is more general than the original one by Efroymson (1964). This program contains an F-test for the introduction and removal of variables in the statistical relation.

We have considered the forty-three F-type stars used by Crawford (1975) for deriving the calibration in luminosity (absolute magnitude M_v). The initial set of parameters known for each star contained the indices β, m_1, c_1, b-y, δm_1, δc_1 and their combinations of second and third order (that is powers and cross products). Several tests have given some good relations with only the indices β, c_1 and their combinations; we have selected the following simple one:

D. S. Hayes et al. (eds.), Calibration of Fundamental Stellar Quantities, 491–494.

$$M_v = -87.8\ c_1 + 10.93\ \beta^2.c_1 - 13.89\ \beta + 44.93 \qquad (1)$$
$$\pm 0.31 \quad \pm 17.6 \quad \pm 2.42 \quad \pm 5.58$$

The standard error in M_v is slightly higher than the error given by Crawford for his calibration. However, we think that the two calibrations are statistically equivalent because an analysis of the (O-C) data has given similar results for both. Indeed, the absolute values of (O-C) have a mean value of 0.23 in our case and 0.24 in Crawford's case.

Relation (1) should be considered as another way of writing the formula

$$M_v = M_v\ (ZAMS,\beta) - f.\delta c_1, \qquad (2)$$

given by Crawford, because M_v (ZAMS,β) depends on β, f is related to β and δc_1 depends on c_1 and β.

Using $[c_1] = c_1 - 0.20$ (b-y) rather than c_1, we obtain a good calibration in terms of luminosity by means of indices which are independent of interstellar extinction. The following formula,

$$M_v = -73.8\ [c_1] + 8.85\ \beta^2[c_1] + 7.71, \qquad (3)$$
$$\pm 0.32 \quad \pm 13.8 \quad \pm 1.81$$

allows us to obtain M_v without a previous determination of the interstellar reddening E(b-y) and its effect on c_1. The error in M_v is close to the respective error for relation (1).

Finally, we have tried to obtain a relation using only the parameters $[m_1]$ and $[c_1]$ (independent of interstellar extinction), because for several distant stars the β index has not been measured.

We have obtained the following equation

$$M_v = -45.63[m_1][c_1] + 18.19[m_1]^2 + 5.00[c_1]^2 + 5.76, \qquad (4)$$
$$\pm 0.35 \quad \pm 7.87 \quad \pm 4.24 \quad \pm 2.10$$

where $[m_1] = m_1 + 0.32$ (b-y). The error in M_v is slightly higher than the error given for relations (1) and (3).

We point out that equations (1) and (3) can be used instead of the calibration given by Crawford (1975), taking into account the same limitations in the indices.

3. SUPERGIANT F-TYPE STARS

3.1. The observational data.

We have searched for supergiant stars in binary stars and multiple systems with spectral type from about A9 to G2 and with known uvby,β indices (Hauck and Mermilliod 1980). We have found only nine

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stars in open clusters; three of them are Cepheids (Fernie and McGonegal 1983). We have considered also thirteen bright Cepheids whose absolute magnitude has been obtained by means of the Period-Luminosity relation given by Fernie and McGonegal (1983). The sample contains peculiar objects such as Y Oph and the second overtone pulsator HR 7308 and Cepheids probably in binary systems; moreover, the photometric indices used in the analysis are generally the mean of a very small number of measures; hence they could give poor estimates of the true mean values. In spite of these limitations, however, the analysis has yielded some interesting results.

3.2. The calibration.

In order to avoid problems due to interstellar extinction, we have considered only the indices β, $[m_1]$, $[c_1]$ and their combinations (second order), that is, a set of nine variables.

A good relation we have obtained is the following one,

$$M_v = \underset{\pm 0.54}{121.01[m_1]} - \underset{\pm 9.52}{168.6[m_1]^2} - \underset{\pm 14.8}{20.68[m_1][c_1]} - \underset{\pm 3.60}{19.46}, \quad (5)$$

which contains only $[m_1]$, $[c_1]$ and their combinations. A better relation contains also β as follows:

$$M_v = \underset{\pm 0.42}{108.98[m_1]} - \underset{\pm 8.32}{146.8[m_1]^2} - \underset{\pm 13.4}{27.22[m_1][c_1]} \underset{\pm 3.45}{} + \underset{\pm 6.11}{20.51\beta} - 70.61. \quad (6)$$

We have made several tests in order to check the reliability of equations (5) and (6). The effect of β is weak, and, for our purposes, equation (5), taking into account our previous discussion on the observational data, should be sufficient.

We can conclude that, in spite of the fact that the data are not of excellent quality, it is possible to evaluate the absolute magnitude of a supergiant star, and equations (5) or (6) can be considered as preliminary calibrations in terms of luminosity for stars with spectral type from F0 to G2 and luminosity class II-I. Our sample contains a small number of stars; in a future paper we will extend the sample, taking into account the photometric data for other Cepheids.

4. REFERENCES

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DISCUSSION

PHILIP: What is the error in your absolute magnitudes?

ANTONELLO: The standard deviation is 0.4 in M_V.

JASCHEK: What standards did you use for the calibration of absolute magnitude?

ANTONELLO: I used nine stars in open clusters and 13 bright Cepheids.

JASCHEK: Could you deredden all your stars with the same procedure?

ANTONELLO: I've used indices entirely independent of reddening.

JASCHEK: Are there no local differences in reddening?

ANTONELLO: No.