THE Hγ-ABSOLUTE MAGNITUDE CALIBRATION

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Abstract. A new calibration of Hγ equivalent widths is presented. Unlike Petrie's method, the new calibration does not require an estimate of the luminosity class or spectral type of the star. A brief comparison with other calibrations is made.

This paper briefly describes an investigation of the Hγ calibration recently completed in collaboration with Mr L. Balona of Witwatersrand University.

Although Petrie's (1965) calibration of Hγ equivalent widths appeared to give cluster distance moduli in good agreement with the photometrically-determined moduli, Petrie himself noted that there was a difference of +1.3 mag, between his calibration and the MK (Blaauw, 1963) calibration for O6–8 stars and +0.6 mag. for O9–B2 main sequence stars. These differences led us to re-examine Petrie's calibration and to reconstruct a new calibration based on more extensive data.

We used Petrie's Hγ equivalent widths (W) of stars in the Pleiades, α Per, Ori OB1 and Per OB1, supplemented by our measurements of W in NGC 3293, NGC 4755, IC 2944, Sco-Cen and h Per. The Sco-Cen data provides a better overlap between the α Per and Ori OB1 sequences; the extension of the observations in h Per to fainter stars and the addition of NGC 3293 and NGC 4755 strengthened the early B and supergiant calibrations and the substitution of IC 2944 for Mon OB1 (used by Petrie) improved the O star calibration. The calibration was carried out independently by each of us using slightly different data; L. Balona (L. B.) preferred to correct each star individually for absorption while D. Crampton (D. C.) used mean cluster absorption wherever possible ($R=3$ was assumed). The Sco-Cen data was not used by D. C either.

Petrie demonstrated that the relationship between the absolute magnitude, M, and W is little affected by stellar rotation or moderate age effects so that M is primarily a function of W with a slight dependence on the spectral type, S. Instead of adopting, as Petrie did, 'spectral-type corrections' which differ for class V–II stars and for class I stars we adopted a method which allows a smooth variation with luminosity class, L, and substituted W itself as a quantitative estimate of L. In each cluster curves of constant S were drawn in the $V_0 - W$ diagram and V_0 was changed relative to the Pleiades to ensure the best continuation of the curves. This gives the distance moduli with respect to the Pleiades for each cluster and we decided to adopt 5.55 mag. as the distance modulus of the Pleiades. The resulting distance moduli are given in the second column of Table I.

For $W<16$ it was found empirically that the interpolation formula

$$M = a + b \log_{10} W$$

fitted the data for a given S very well. We experienced considerable difficulty, however,

B. Hauck and B. E. Westerlund (eds.), Problems of Calibration of Absolute Magnitudes and Temperature of Stars, 120–123.

TABLE I

Distance moduli determined for clusters used in the calibration

Cluster	Distance modulus from fitting procedure	Distance modulus from calibration	No. of stars
Pleiades	5.55	5.53 ± 0.08	17
α Per	6.20	6.21 ± 0.07	27
Sco-Cen	6.45	6.49 ± 0.07	65
Ori OB1	8.15	8.12 ± 0.07	43
h & χ Per	11.45	11.46 ± 0.07	56
NGC 4755	11.85	11.75 ± 0.08	22
NGC 3293	12.35	12.32 ± 0.09	23
IC 2944	12.00	12.04 ± 0.11	21

in attempting to fit a smooth continuous curve through the variation of the coefficients a and b with S. Two solutions were adopted; (1) two curves were derived for a

$$\text{Viz; } a = -21.82 + 1.949S - 0.0696S^2 \quad S > 14$$
$$a = -9.28 + 0.257S - 0.0133S^2 \quad S \leqslant 14$$
$$b = 10.40 - 0.537S + 0.026S^2,$$

where $S=6$ at O6 and increase by unity for each later spectral subclass reaching $S=23$ at A3 and (2) $(B-V)_0$ was substituted for S and an independent relation between M and W was found:

$$M_v = -9.72 - 7.18(B-V)_0 + 9.88 \log_{10} W + 9.66(B-V)_0 \log_{10} W$$
$$\begin{pmatrix} W < 14A \\ (B-V)_0 < 0 \end{pmatrix}.$$

The two calibrations are, of course, not identical but the differences are small, particularly for main sequence stars. The mean difference between calibrations 1 and 2 is -0.04 mag. with a dispersion of 0.2 mag. It should be noted that for most stars $(B-V)_0$ can be derived from the UBV colours alone and then no knowledge of the spectral type is required to use calibration 2.

The mean distance moduli, derived from the two calibrations, of the clusters used in the calibration are listed the third column of Table I. The distance moduli are in good agreement with those from other recent determinations with the exception of Sco-Cen for which a value of 6.0 is more usual. There is considerable scatter among the distance moduli of the individual members of this group but the reason for the difference between our determination and the others is not understood. The average dispersion in absolute magnitude about the calibration ranges from 0.3 mag. for late B main sequence stars to 0.6 mag. for O, early B and supergiant stars; the mean dispersion for all stars is 0.5 mag.

The difference between the absolute magnitude derived from Petrie's calibration and that from calibration 1 is shown plotted as a function of spectral type in Figure 1.

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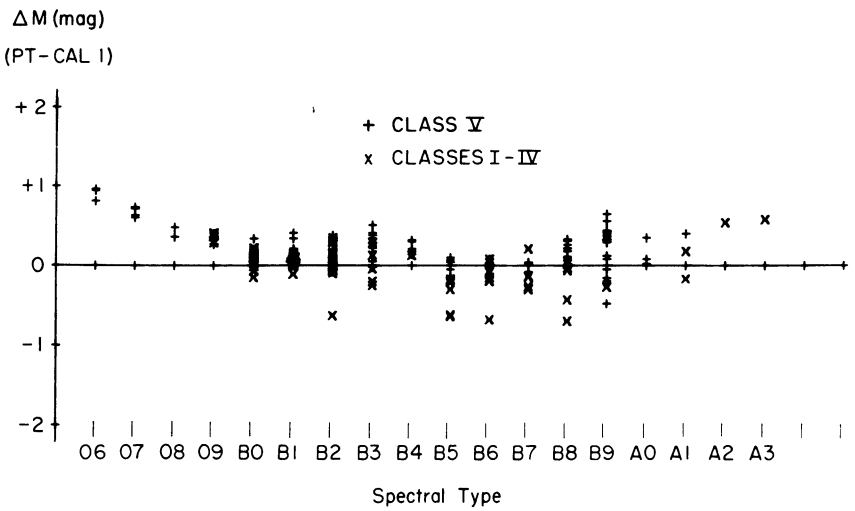

Fig. 1. Difference between the absolute magnitude derived from Petrie's calibration and calibration 1 vs spectral type.

It may be readily seen that the absolute magnitudes derived from the new calibration are up to 1 mag. brighter for the O stars but the agreement is surprisingly good for all other spectral types.

A preliminary comparison with the MK calibration tabulated by Blaauw (1963) based on a large number of stars with measured W indicates that our calibration is (1) ~ 0.4 mag. fainter than the MK calibration for class III–V stars earlier than B2, (2) about -0.3 mag. brighter for B3–6 class V stars, and (3) brighter for the supergiants earlier than B3 (our calibration gives $M_v \sim -7.0$ for all B0–A1 class Ia stars). We are in excellent agreement with the recent calibration given by Walborn (1972) for stars of spectral type earlier than B3.

In summary, we have improved Petrie's calibration, particularly for the O stars, and have devised a new method of calibration which does not require an estimate of the luminosity class of the star or its spectral type in order to determine its absolute magnitude.

References

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DISCUSSION

Van den Bergh: Could the grey absorbing shells that Strom and others have recently found around *faint* young stars have affected the main sequence fitting used for your calibration of bright stars in very young clusters? In particular might this effect account for the observed discrepancy between the new distance modulus of Scorpio-Centaurus and previous values obtained from proper motions?

Crampton: In most of the clusters we used this effect is probably negligible. However, the systematic error in Petrie's calibration for the O stars may be partly due to such an effect in NGC 2244. I would not expect the effect to be large in the stars we observed in Scorpio-Centaurus.

Newell: Are all your spectra exposed for radial velocities and, if so, are they not too dense for the determination of spectrophotometric quantities?

Crampton: Hγ measurements are only made on spectra which are, in fact, suitable for spectrophotometry but, in general, the plates are not too dense.

Jones: Could you comment on the fact that while you place Scorpio-Centaurus $0^{m}.65$ further away than I do, you find corrections to main-sequence B stars in exact agreement?

Crampton: The reason for this is not immediately obvious, however, members of the Scorpio-Centaurus association have very little weight in the determination of the mean absolute magnitude.

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