# THE ZERO-POINT OF THE CEPHEID LUMINOSITY SCALE FROM A CALIBRATION OF THE LUMINOSITIES OF EARLY-TYPE STARS

L.A. Balona
South African Astronomical Observatory

R.R. Shobbrook
University of Sydney

Abstract. A new calibration of the absolute magnitudes of early-type stars in terms of the ($\beta$, $c_0$) photometric system is used to establish the distance moduli of clusters containing Cepheids. The zero points of the period - luminosity and period - luminosity - colour relations are calculated and compared to previous determinations.

We have used published uvby$\beta$ photometry of young clusters to calibrate the absolute magnitudes of early-type stars in terms of the $\beta$ and $c_0$ indices (Balona & Shobbrook 1984). A total of 421 stars in 13 open clusters is used. All the clusters independently tie up with the Pleiades sequence, which eliminates a major source of uncertainty in previous calibrations. Our calibration is:

$$M_V = 3.499 + 7.203 \log(\beta - 2.515) - 2.319[g] + 2.938[g]^3$$

where $[g] = \log(\beta - 2.515) - 1.60 \log(c_0 + 0.322)$. This is valid for all luminosity classes.

This calibration was applied to eight galactic clusters containing Cepheids. Table 1 shows the resulting distance moduli based on uvby$\beta$ photometry by Schmidt (1980ab, 1981, 1982ab, 1983). Also shown are distance moduli obtained by Schmidt using Crawford's (1978) calibration and distance moduli by Caldwell (1983) using zero-age main sequence fitting with the revised Hyades distance.

Table 1. Distance moduli of clusters containing Cepheids. N is the number of stars used in Schmidt's and our determinations.

| Cluster | $V_0-M_V$ | N | Schmidt | Caldwell |
|---|---|---|---|---|
| NGC129 | 11.07 ± 0.04 | 11 | 10.9 ± 0.1 | 11.12 |
| NGC6087 | 9.64 ± 0.09 | 11 | 9.6 ± 0.1 | 9.81 |
| NGC6664 | 10.90 ± 0.12 | 11 | 10.7 ± 0.1 | 10.88 |
| NGC7790 | 12.15 ± 0.10 | 13 | 12.0 ± 0.1 | 12.69 |
| IC4725 | 8.91 ± 0.08 | 27 | 8.8 ± 0.1 | 9.14 |
| CV Mon | 11.35 ± 0.24 | 5 | 10.9 ± 0.3 | 11.35 |
| Ru 79 | 11.83 ± 0.21 | 5 | 11.4 ± 0.3 | 12.33 |
| Ly 6 | 10.55 ± 0.10 | 3 | 10.6 ± 0.3 | 10.84 |

https://doi.org/10.1017/S0252921100109315 Published online by Cambridge University Press

The distance moduli of Ru 79 and Ly 6 differ from the distance moduli of the corresponding Cepheids by about one magnitude, no matter which Cepheid calibration is used. Omitting these two stars, we can use the above moduli to fix the zero points of the period - luminosity (PL) and period - luminosity - colour (PLC) relationships as defined by Caldwell (1983). We then obtain the following calibrations:

$$\langle M_V \rangle = -2.79 \log P - 1.14 \quad (\pm 0.11)$$
$$\langle M_V \rangle = -3.80 \log P + 2.70(\langle B \rangle_0 - \langle V \rangle_0) - 2.19 \quad (\pm 0.06)$$

The PLC relation leads to absolute magnitudes which are fainter by 0.27 ± 0.08 mag than Caldwell's. Schmidt's distance moduli lead to absolute magnitudes 0.42 ± 0.10 fainter than Caldwell's.

The greatest uncertainty arising from ZAMS fitting is the poorly defined sequences in most of the calibrating clusters. Differences of as much as one magnitude are known to occur in the estimation of the distance moduli using this method. For this reason, the absolute magnitude estimates using uvbyβ photometry are expected to be more reliable, even though fewer stars are used. The standard deviation for one star in the absolute magnitude calibration is 0.4 mag, so that measurements of just a few stars should enable distance moduli to be obtained accurate to better than 0.2 mag.

A serious source of uncertainty which could affect the above calibration for Cepheids is the possibility of a systematic error in Schmidt's β index arising from systematic errors in the standard stars. There is no reason to suspect that this is the case, but differences of as much as 0.01 mag in β between different workers are not unknown. This could lead to zero point errors of as much as 0.3 mag in the PL and PLC relationships. For this reason it is important to obtain independent β observations for stars in the clusters containing Cepheids.

In conclusion, we find that a slight downward revision of the luminosities of Cepheids is indicated. The zero points determined by Caldwell (1983) are, however, within the uncertainties at present. The much lower luminosities found by Schmidt reflects the difference between Crawford's calibration and our calibration for the mid- to late-B stars.

## REFERENCES

Balona, L.A. & Shobbrook, R.R., 1984. Mon. Not. R. astr. Soc., in press.
Caldwell, J.A., 1983. Observatory, 103, 244.
Crawford, D.L., 1978. Astr. J., 83, 48.
Schmidt, E.G., 1980a. Astr. J., 85, 158.
Schmidt, E.G., 1980b. Astr. J., 85, 695.
Schmidt, E.G., 1981. Astr. J., 86, 242.
Schmidt, E.G., 1982a. Astr. J., 87, 650.
Schmidt, E.G., 1982b. Astr. J., 87, 1197.
Schmidt, E.G., 1983. Astr. J., 88, 104.

https://doi.org/10.1017/S0252921100109315 Published online by Cambridge University Press