

Independent Distance Determinations to Milky Way Cepheids in Open Clusters: A progress report on four stars

Wolfgang P. Gieren¹, Jaymie M. Matthews²
Jean-Claude Mermilliod³ & Douglas Welch⁴

¹*Pontificia Universidad Católica de Chile, Santiago, Chile*

²*University of British Columbia, Vancouver, Canada*

³*Université de Lausanne, Switzerland*

⁴*McMaster University, Hamilton, Canada*

Abstract. We have undertaken a programme to calibrate the Cepheid PL relation zero-point by obtaining distances of Cepheids in open clusters and associations via the visual surface brightness technique. Results are now available for four stars (SZ Tau, CF Cas, CV Mon and DL Cas) and others are currently under analysis. Preliminary results suggest the ‘ZAMS-fitting’ distances to the host clusters are systematically smaller than those we derive from Cepheid surface brightnesses.

1. Introduction

One of the most nagging contributors to uncertainty in the intergalactic distance scale remains the calibration of Galactic Cepheids. We are currently deriving distances to Cepheids in open clusters and associations independent of ZAMS-fitting and/or $H\beta$ calibrations.

Our approach is to apply the “visual surface brightness” method (Barnes & Evans 1976) – a variant of the classical Baade-Wesselink technique – using new high-quality radial velocity measurements supplemented by velocity and photometric data from the literature. This allows us to compare our results with the period-luminosity (PL) calibration of Gieren, Barnes & Moffett (1993), who obtained distances to 100 Galactic Cepheids by the same method. Our ultimate goal is to calibrate the zero point of the PL relation to within a few $\times 0.01$ mag, compared to current accuracies of ± 0.1 (cf. Gieren & Fouqué 1993).

The present uncertainty is not surprising, given the many problems associated with ZAMS fitting to derive distances of Galactic clusters containing Cepheid variables. Strong visual extinction (varying across the cluster field), main-sequence bands which are often poorly defined in observed colour-magnitude diagrams (CMDs), contamination by field stars, and the difficulty in finding a ZAMS fiducial appropriate for a cluster are among the most serious sources of error.

2. DL Cas in NGC 129; CF Cas in NGC 7790

As an eight-day Cepheid which is both a component of a spectroscopic binary and a member of the open cluster NGC 129, DL Cas should be a very accurate calibrator of the PL relation and Cepheid mass. From 160 high-precision ($\sigma < 1$ km/s) radial velocity observations made with the CORAVEL and DAO spectrometers - including 67 new unpublished data - we have obtained both the orbital and pulsational velocity curves of this binary Cepheid (Gieren et al. 1994). This body of RV data makes DL Cas one of the best observed Cepheids in our Galaxy. The radius of $66.0 \pm 3.5 R_{\odot}$ we derive indicates that DL Cas is a fundamental-mode pulsator, removing any ambiguity in mode identification.

Containing three Cepheids and an eclipsing binary, the open cluster NGC 7790 has the potential to be a Rosetta Stone for refining the zero-point of the extragalactic distance scale. Unfortunately, ZAMS fitting of this relatively sparse, heavily reddened cluster is fraught with difficulty, and even modern determinations of its distance modulus based on comparable data and techniques differ by over 0.3 mag. To provide an independent calibration of the distance to NGC 7790, we have performed a surface brightness analysis of one of its Cepheids, CF Cas ($P \simeq 4.88$ days). Our new measurements almost double the published RV data for this star (Matthews et al. 1995, submitted).

3. Checking the ZAMS calibration

With our results for four stars, we have taken the first step towards checking for any systematic differences between the ZAMS-fitting and surface brightness calibrations. Our initial findings are summarised below. We have another four stars in our main programme and several other possible candidates, which should allow us to make a realistic comparison of the two zero-point systems, tied in to the extensive study of field Cepheids by Gieren, Barnes & Moffett (1993).

Cepheid	log P (d)	Distance (parsecs)	$(m - M)_{\text{ZAMS}}$	$(m - M)_{\text{SB}}$
SZ Tau	0.4982	580 ± 040	8.68	8.82
CF Cas	0.6875	3230 ± 160	12.34 - 12.65	12.55
CV Mon	0.7307	2160 ± 150	11.22	11.67
DL Cas	0.9031	2034 ± 110	11.11	11.54

References

- Barnes, T.G., & Evans, D.S. 1976, MNRAS, 174, 489
 Gieren, W.P., Barnes, T.G., & Moffett, T.J. 1993, ApJ, 418, 135
 Gieren, W.P., & Fouqué, P. 1993, AJ, 106, 734
 Gieren, W.P., et al. 1994, AJ, 107, 2093
 Matthews, J.M., et al. 1995, AJ, submitted