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The distance to the Small Magellanic Cloud from multiband period-luminosity relations for classical Cepheids and its dependence on metallicity

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Abstract. We present a distance determination to the Small Magellanic Cloud (SMC) using optical and near-infrared photometry from OGLE and IRSF. Applying a multiband method to V, I, J, H and K OGLE and IRSF data, we measured the SMC true distance modulus and mean reddening. Comparing our results with accurate distances to the LMC and SMC obtained from eclipsing binary systems, we conclude that the dependence of Cepheid magnitudes on metallicity is very small (< 0.07 mag/dex) in all bands.

1 Introduction

The Magellanic Clouds, two companions of our Galaxy containing huge numbers of distance indicators, constitute a milestone towards precise and accurate calibration of the cosmic distance scale. While the distance to the Large Magellanic Cloud (LMC) is an excellent zero point for the whole extragalactic distance scale, the Small Magellanic Cloud (SMC) allows us to examine how primary standard candles depend on metallicity. Distances to these galaxies have been measured many times with different methods, and, in particular, using a geometric method based on eclipsing binary systems ([1, 2]). Recent determinations of the SMC distance moduli are very close to 19.0 mag, but the spread around this value, dominated by systematic errors, is larger than 0.6 mag.

2 Data and results

Coordinates of Cepheids, optical V and I photometry and periods of pulsation come from the OGLE III catalogue ([3–5]). Infrared photometry in J, H, K bands is taken from IRSF observations ([6]). From our sample of Cepheids in the SMC, we removed stars with periods shorter than 2.5 d due to the observed nonlinearity of the period-luminosity (P-L) relation in this region.

In order to derive extinction-free P-L relations in the LMC, we used extinction maps published by [7], Galactic extinction towards the LMC from [8], and reddening law by [9]. With the method of least-squares and 3-sigma clipping, we established the Cepheid P-L relations in the LMC. Adopting

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the slopes of the LMC Cepheid P-L relations, we calculated zero points for the P-L relations in the SMC with the least-squares method. The difference in zero points of P-L relations in SMC and LMC in each band is the observed relative distance modulus of these galaxies (i.e., affected by mean extinction towards the SMC Cepheids). Applying a multiband method (e.g., [1]), we found the true relative distance modulus of the SMC and LMC and mean reddening towards the SMC Cepheids. Our results are 0.482 ± 0.005 mag and 0.094 ± 0.004 mag for the relative distance modulus and mean reddening, respectively. Assuming a distance modulus of the LMC of 18.493 mag ([2]), we obtain a distance modulus of the SMC of 18.975 mag.

3 Discussion

Our relative distance determination is in very good agreement with the very accurate [10] determination from late-type eclipsing binaries, which amounts to 0.472 ± 0.026 mag. Assuming that the difference between the relative distance moduli between the LMC and SMC obtained from eclipsing binaries and Cepheids is due to metallicity, we conclude that the metallicity effect on the Cepheid brightness in all bands is very small (< 0.07 mag/dex), and within the errors is consistent with zero. More accurate determination of the metallicity effect require better SMC distance determination from the eclipsing binaries and better determination of Cepheid metallicities in both galaxies. It is worth noticing that our current SMC distance determination from Cepheids is very slightly sensitive to the adopted reddening law, which usually is a very important contribution to the total error budget.

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