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ORIGINAL ARTICLE

Ultra long period Cepheids: a primary standard candle out to the Hubble flow

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Abstract The cosmological distance ladder crucially depends on classical Cepheids (with $P = 3$–80 days), which are primary distance indicators up to 33 Mpc. Within this volume, very few SNe Ia have been calibrated through classical Cepheids, with uncertainty related to the non-linearity and the metallicity dependence of their period–luminosity (PL) relation. Although a general consensus on these effects is still not achieved, classical Cepheids remain the most used primary distance indicators. A possible extension of these standard candles to further distances would be important. In this context, a very promising new tool is represented by the ultra-long period (ULP) Cepheids ($P \gtrsim 80$ days), recently identified in star-forming galaxies. Only a small number of ULP Cepheids have been discovered so far. Here we present and analyse the properties of an updated sample of 37 ULP Cepheids observed in galaxies within a very large metallicity range of $12 + \log(\mathrm{O/H})$ from ∼7.2 to 9.2 dex. We find that their location in the colour-magnitude $(V - I, V)$ diagram as well as their Wesenheit $(V - I)$ index-period (WP) relation suggests that they are the counterparts at high luminosity of the shorter-period ($P \lesssim 80$ days) classical Cepheids. However, a complete pulsation and evolutionary theoretical scenario is needed to properly interpret the true nature of these objects. We do not confirm the flattening in the studied WP relation suggested by Bird et al. (Astrophys. J. 695:874, 2009). Using the whole sample, we find that ULP Cepheids lie around a WP relation similar to that of the LMC, although with a large spread (∼ 0.4 mag).

Keywords Extragalactic distance scale · Variable stars · H_0 measurement

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1 Introduction

The two most popular routes to estimating the Hubble constant H_0 involve the Cosmic Microwave Background (CMB) and the Supernovae type Ia (SNe Ia). The WMAP experiment (Komatsu et al. 2011) measures a precise time since recombination, and makes a strong case for a flat Universe. However, this measurement of the local expansion rate relies on the adopted cosmological model and on the priors (list of cosmological parameters) adopted in dealing with the CMB map. The SNe Ia provide an independent estimate of H_0. The absolute calibration of the SNe Ia luminosity peak is currently anchored to the Cepheid-based distances to a dozen nearby host galaxies, and for this reason Cepheids are the cornerstone for the absolute calibration of the extragalactic distance scale (e.g. Freedman et al. 2001; Saha et al. 2001). However, the universality of the Cepheid PL relation, and the possibility that the slope and/or the zero-point of the PL relation might depend on the chemical composition, have been lively debated for almost two decades (see e.g. Kennicutt et al. 1998; Fiorentino et al. 2002;