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ORIGINAL ARTICLE

Period-luminosity relations for Cepheid variables: from mid-infrared to multi-phase

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Abstract This paper discusses two aspects of current research on the Cepheid period-luminosity (P-L) relation: the derivation of mid-infrared (MIR) P-L relations and the investigation of multi-phase P-L relations.

The MIR P-L relations for Cepheids are important in the *James Webb Space Telescope* era for the distance scale issue, as the relations have potential to derive the Hubble constant within $\sim 2\%$ accuracy—a critical constraint in precision cosmology. Consequently, we have derived the MIR P-L relations for Cepheids in the Large and Small Magellanic Clouds, using archival data from *Spitzer Space Telescope*. We also compared currently empirical P-L relations for Cepheids in the Magellanic Clouds to the synthetic MIR P-L relations derived from pulsational models.

For the study of multi-phase P-L relations, we present convincing evidence that the Cepheid P-L relations in the Magellanic Clouds are highly dynamic quantities that vary significantly when considered as a function of pulsational phase. We found that there is a difference in P-L relations as a function of phase between the Cepheids in each of the Clouds; the most likely cause for this is the metallicity difference between the two galaxies. We also investigated the dispersion of the multi-phase P-L relations, and found that the minimum dispersions do not differ significantly from the mean light P-L dispersion.

Keywords Stars: variables: Cepheids · Distance scale

1 Introduction

The period-luminosity (P-L, also known as Leavitt Law) relation for Cepheid variables is an important astrophysical tool. A calibrated P-L relation can serve as the first rung in the extragalactic distance scale ladder, which can be used to determine the Hubble constant (e.g., Freedman et al. 2001; Sandage et al. 2006; Riess et al. 2011, and reference therein). In the local Universe, the Cepheid P-L relation can be used to measure the distances to nearby galaxies and investigate the characteristics of our own Galaxy (e.g., Majaess et al. 2009; Pedicelli et al. 2009, and reference therein). Research on Cepheid P-L relations includes calibrating the relations (e.g., Fouqué et al. 2007, and reference therein), investigating the metallicity dependence (e.g., Romaniello et al. 2008 and reference therein) or universality of the P-L relations (e.g., Bono et al. 2010, and reference therein), and the study of non-linearity of these relations (e.g., Ngeow et al. 2009, and reference therein). These works mainly focused on mean light in the optical and near infrared (JHK) bands. In this paper, we discuss two aspects of current research in P-L relations: the extension of the P-L relations to mid-infrared (Sect. 2), and the investigation of P-L relations at various phases of the pulsation—the multi-phase P-L relations (Sect. 3).

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