New insights into the Cepheid PL relation through the use of multiphase relations

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Abstract The Cepheid Period-Luminosity (PL) relation is of fundamental importance in the extra-galactic distance scale. Usually this relation is considered at mean light. We show, using OGLE-III data, how a deeper understanding of the metallicity dependence of the Cepheid PL relation can be gained by considering how this relation varies as a function of pulsation phase in the Large (LMC) and Small (SMC) Magellanic Clouds. We also consider the Wesenheit function and show that it too is highly dynamic and nonlinear for many pulsational phases. We discuss possible implications for Cepheid modeling and the extra-galactic distance scale.

1 Introduction

The luminosity of a Cepheid star relates positively to the duration of its pulsational period. Closely related to the PL relation is the reddening independent Period-Wesenheit (PW) relation, where $W = I - 1.55(V - I)$. Having a better understanding of how these relations manifest in external galaxies would improve calculations of cosmic distances and hence enable an accurate determination of the Hubble constant.

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2 Multiphase Relations

The Cepheid PL and PW relations are typically investigated using mean light. However, doing this ignores the multitude of magnitudes exhibited by these objects. The technique of multiphase relations remedies this problem by instead considering magnitude at each individual point of pulsational phase. For the purpose of comparison, light curves are shifted so that phase zero corresponds to maximum light and a full pulsation is completed at phase one.

3 Metallicity Dependency

We compared the behavior of the multiphase PL and PW relations in the LMC and SMC. We performed Fourier decompositions on almost 8,000 Cepheids observed in the V and I passbands by the OGLE-III group [1, 2]. We reduced each dataset using published reddening maps. We distinguish short period Cepheids, whose periods are between about two and ten days, from long period Cepheids, whose periods are greater than ten days.

We found that the slopes and zero-points of the multiphase Cepheid PL and PW relations in the LMC and SMC do not coincide for many pulsational phases. This is strong evidence for these relations to be metallicity dependent. We also found that the relations for short and long period Cepheids behave differently, providing more confirmation for their nonlinearity. The largest disparities come from the relations of long period Cepheids, which is significant because these are the objects most commonly used to measure distances. A better understanding of the effects that metallicity has on the Cepheid PL and PW relations will be necessary to calibrate them properly.

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