Toward a Universal Period-p-factor Relation

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The parallax-of-pulsation (PoP) method, best known for its photometric variant as the Baade-Wesselink (BW) method, is the most common way to have independent distance measurements by combining the stellar linear radius with the angular diameter variations. The linear radius is estimated via radial velocities that are converted to pulsation velocities by conventionally choosing a multiplicative factor, called the p-factor. This factor depends on the limb darkening and the dynamical behaviour of the line-forming regions, which is rather difficult to quantify without a detailed modelling of the stellar atmosphere. This parameter is currently the main source of uncertainty in the application of the PoP method, leading to a global uncertainty of about $5-10\,\%$ on the distance. Here we present an empirical approach which makes use of the Spectro-Photo-Interferometry of Pulsating Stars (SPIPS) algorithm to derive a period-p-factor relation for Galactic (MW) and Magellanic Cloud (MC) Cepheids.

1 Introduction

To calibrate the zero point of period-luminosity relation, independent distance measurements of some Cepheids are needed. The most common method for that is the BW technique which combines linear radius (R) and angular diameter (θ) variations:

$$\theta(t) - \theta(0) = \frac{2[R(t) - R(0)]}{d} = \frac{2p}{d} \int_0^t v_{\rm puls}(\tau) d\tau,$$

with d the distance. We see that the p-factor, which transforms radial velocities to pulsation velocities, is degenerate with the distance. One has to be known to determine the other. There is no agreement in the literature about the optimum value of p. Different authors use either a constant value (between 1.2 to 1.5) or a linear dependence with the pulsation period. However, that dependence differs between authors (see e.g. Storm et al., 2011; Nardetto et al., 2014). An observational

calibration is possible if the distance to the Cepheid is known, as demonstrated in our previous work (see e.g. Breitfelder et al., 2015). Our more recent analyses with the SPIPS algorithm (Mérand et al., 2015) suggest a mildly variable p-factor with respect to the pulsation period (Breitfelder et al., 2016; Kervella et al., 2017). SPIPS is a generalized PoP implementation, which includes many more observables than the traditional BW implementations that use only two photometric bands and radial velocities.

2 Results

With the accurately known LMC and SMC distances (Pietrzyński et al., 2013; Graczyk et al., 2014), we performed SPIPS modeling of a sample of 29 LMC and 10 SMC Cepheids to derived their p-factor, together with other stellar parameters (Gallenne et al., 2017). Combining this sample with our previous MW results, we confirm a global linear relation $p = -0.08(\log P - 1.18) + 1.24$, consistent with previous works. A new calibration of the period-radius relation has been also derived with a smaller intrinsic dispersion of ± 0.02. Finally, we also detected IR excesses at 3.6μm and 4.5μm, which might be the signature of the presence of circumstellar dust.

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