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Precise distances to red giant stars with seismic data using the near-IR surface-brightness relation

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Abstract. The Kepler and CoRoT satellites have determined precise asteroseismic radii for large samples of red giant stars. Combining these data with data from spectroscopic and photometric surveys has led to precise distance determinations using comprehensive Bayesian methods. Here we determine angular diameters and thus distances using the interferometrically calibrated near-IR surface-brightness method finding good agreement with previous results. The method can easily be reversed when accurate Gaia parallaxes for these stars become available to calibrate the asteroseismic scaling relations.

Keywords. stars: distances, stars: late-type, stars: oscillations

1. Stellar distances

Stellar distances can be determined geometrically if the stellar radius and angular diameter is known. Asteroseismology allows the determination of precise stellar radii and the near-IR surface-brightness relation allows the determination of accurate stellar angular diameters for red giant stars. This direct empirical approach can eventually be compared with Gaia parallaxes and provide a direct and accurate calibration of the asteroseismic scaling relation. Rodrigues *et al.* (2014) have published precise distances for a large sample of Kepler red giant stars with APOGEE spectra (APOKASC, Pinsonneault *et al.* (2014)) based on a comprehensive Bayesian analysis of the asteroseismic, spectroscopic and photometric data. Asteroseismology allows the determination of stellar radii based on a scaling relation depending on two seismic parameters as well as the square root of the effective temperature. We use the asteroseismic parameters from the APOKASC database for this purpose. Angular diameters, Θ, for nearby red giant stars have been measured accurately with interferometers. The surface-brightness parameter, S_V, is defined as $S_V = V_0 + 5\log(\Theta)$ and has been shown to follow a tight relation, very weakly dependent on metallicity, with the $(V-K)_0$ color index, e.g. di Benedetto (2005). In fact this very relation has been applied to red giant eclipsing binary stars to determine the currently most accurate distance to the Large Magellanic Cloud (Pietrzynski *et al.* (2013)).

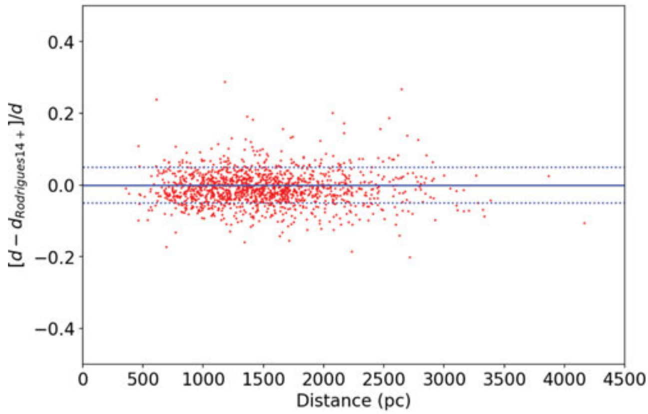

Figure 1. The relative distance differences between the near-IR surface-brightness method based distances and those determined by Rodrigues *et al.* (2014) based on a Bayesian analysis of asteroseismic, spectroscopic and photometric data for red giants in the Kepler field plotted against our distances. The offset is less than 1% and the standard deviation is less than 5%. The ±5% level is indicated with the dotted lines.

2. Reddening and effective temperature

We have adopted the same reddening values as given in the Kepler database and as used by Rodrigues *et al.* (2014). We have adopted the $(V - K)$ temperature scale from Gonzales Hernandez & Bonifacio (2009) as this colour index is very tightly correlated with $T_{\rm eff}$ for red stars and is only very weakly dependent on metallicity. This calibration is furthermore based exclusively on red giant stars. Adopting other recent calibrations like Casagrande *et al.* (2010) affects the distances at less than the 1% level.

3. Results

As can be seen in Fig.1 the new distances agree with the Rodrigues *et al.* (2014) values to within 1% with a standard deviation of only 5%. We can thus confirm the results of the comprehensive Bayesian analysis while relying on a significantly reduced data set. Storm *et al.* (in prep) find a similar result for the CoRoT sample analyzed by Anders *et al.* (2017). With Gaia DR2 parallaxes it will become possible to accurately calibrate the asteroseismic scaling relations directly to the fundamental distance scale using the empirically determined surface-brightness relation, thus significantly reducing the dependence on stellar atmosphere models.

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