Abstract

Distance determinations are among the essential tasks of observational astronomy. Different methods that are subject to different systematic errors allow checking consistency and accuracy of distance determinations. Techniques of partially overlapping and increasing ranges constitute the *cosmic distance ladder*, whose calibration is pivotal in determining the *Hubble constant*. These are especially the nearby galaxies that provide excellent opportunities for testing different distance determination methods.

In my dissertation, I present three different distance determination methods based on two types of stellar distance indicators.

The first part of my thesis presents a new calibration of a distance determination method based on mean values of luminosity functions of carbon stars in the near-infrared (NIR) $J-$band. The calibrated mean absolute magnitude of carbon stars is -6.212 ± 0.010(stat.)± 0.030(syst.) mag. I further use the new calibration to determine distances to nine nearby galaxies and compare my results with the corresponding results from classical Cepheids. I obtain a very good agreement between the two methods, with the mean distance difference of 0.01 mag and the corresponding standard deviation of 0.06 mag.

In the second part of the thesis, I describe two distance determination methods based on RR Lyrae stars. I provide a new calibration of the period-luminosity (PL) and period-luminosity-metallicity (PLZ) relations in NIR bands for RR Lyrae stars from the Milky Way. I compare my calibrations with the recent findings available in the literature, and I determine distances to four nearby galaxies. The zero point of my calibrations of period-luminosity-metallicity relations for RR Lyrae stars is in agreement with the very accurate distance to the Large Magellanic Cloud obtained using eclipsing binaries (Pietrzyński et al., 2019). However, my new calibrations yield distances to four nearby galaxies that are smaller by $0.013 - 0.020$ mag compared to distances based on previous calibrations available in the literature. Subsequently, I present my calibration of projection factors and determination of the mean radii for two Galactic RR Lyrae stars. My calibrations for RR Lyrae stars are based on data gathered at the Cerro Armazones Observatory and parallaxes from the Early Data Release 3 of the GAIA space mission.

My research on carbon stars provides a method allowing to determine the Hubble constant, independent of classical Cepheids and the Tip of the Red Giant Branch. The new calibration of P-L-Z relations for RR Lyrae stars allows testing of distance determination methods in the neighborhood of our Galaxy. Relations allow tracing the old stellar Population II. The precision calibration of projection factors for two RR Lyrae stars provides auspicious results and when applied to a larger sample of these stars, may provide a genuine breakthrough in distance determination using this technique.