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Near-infrared observations of RR Lyrae variables in ω Centauri

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Abstract. We present Near-Infrared (NIR) J and K_s-band observations for 181 RR Lyrae stars in the Galactic Globular Cluster ω Cen. The comparison between predicted and empirical slopes of NIR Period-Luminosity (PL) relations indicates a very good agreement. Cluster distance estimates based on NIR PL relations agree quite well with recent determinations based on different standard candles, giving a true mean distance modulus $\mu = 13.71 \pm 0.05$, and $d = 5.52 \pm 0.13$ kpc.

Key words. globular clusters: individual (ω Centauri)–stars: variables:other

1. Introduction

During the last few years, a substantial theoretical effort has been devoted to the pulsational properties of RR Lyrae stars in NIR bands. These investigations rely on predictions based either on pulsational models (Bono et al. 2001, 2003) or on synthetic horizontal branches (Catelan et al. 2004, Cat04; Cassisi et al. 2004, Cas04), and provide PL relations in different NIR bands. However, observations lag theoretical predictions, and in order to fill this observational gap and to validate current predictions concerning NIR PL relations, we have undertaken a long-term project aimed at collecting NIR observations for RR Lyrae stars in clusters in the Galaxy and in the Large Magellanic Cloud.

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2. Discussion of results

The JK_s data for ω Cen were collected using the NIR camera SOFI@NTT. We derived accurate J and K_s light curves for 56 RR Lyrae. Together with these data we extracted from the ESO archive other J and K_s images (Sollima et al. 2004) and we derived a few or single epoch J and K_s measurements for 58 additional RR Lyrae. In order to further increase the sample of RR Lyrae stars we also added the 29 RR Lyrae observed by Longmore et al. (1990) and the 38 RR Lyrae with single epoch J and K_s magnitudes provided by the 2MASS survey.

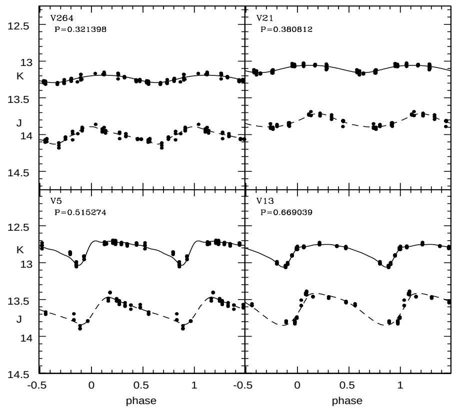

Fig. 1. Well-sampled light curves for two RR*c* and two RR*ab*. Solid and dashed lines show the K-band template fit and the spline fit.

We ended up with a sample of 82 RR*ab* and 99 RR*c* with at least one J or K_s measurement, for a total of 181 out of the 186 RR Lyrae in ω Cen with accurate periods.

The pre-reduction was performed using standard IRAF procedures and the photometry using DAOPHOT/ALLFRAME packages. The absolute calibration in the 2MASS system was performed using ≈400 local standard stars. The accuracy of the absolute zero-point is ~ 0.02 mag. We fitted the individual K_s-band phase points with a template curve (Jones et al. 1996). This method requires for each variable accurate estimates of both the epoch and the luminosity amplitudes, which are only available for the RR Lyrae observed by Kaluzny et al. (2004). The mean J-band magnitude of well-sampled light curves were estimated with a spline fit. Figure 1 shows selected J and K_s-band light curves for two first overtones (RR*c*) and two fundamental (RR*ab*) variables.

To estimate the distance to ω Cen, we adopted the K-band PL relation provided by Cas04, a new J-band PL relation computed using the same evolutionary and pulsation models of Cas04[1], and the J,K-band PL relations provided by Cat04, transformed into the 2MASS NIR system using the transformations provided by Carpenter et al. (2001). By assuming a constant reddening value $E(B-V) = 0.11$ mag, we obtained a true distance modulus $\mu = (J - M_J)_0 = 13.66 \pm 0.07$ mag and $\mu = (K - M_K)_0 = 13.67 \pm 0.04$ mag by adopting the new J-band PL relation and the K-band PL relation given by Cas04. Interestingly enough, the J and K-band PL relations provided by Cat04 give respectively $\mu = 13.75 \pm 0.05$ mag and $\mu = 13.73 \pm 0.04$ mag. These estimates agree, within empirical and theoretical uncertainties, with recent estimates based on different distance indicators, such as an eclipsing binary (Thompson et al. 2001). They are roughly 15% longer than the dynamical distance estimates by van de Ven et al. (2005).

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[1] For Z=0.001 and a HB type=0.90, i.e. the HB type of ω Centauri, we found: $< M_J > = -1.70(\pm0.03)\mathrm{LogP} - 0.624(\pm0.03)$.