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New Accurate Near Infrared Photometry of the Galactic Globular Cluster M5

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Abstract. We present a preliminary analysis of our deep Near-Infrared (NIR) photometry of the Galactic Globular Cluster NGC5904 (M5), based on data collected with SOFI at New Technology Telescope (NTT) (ESO, La Silla) and NICS at Telescopio Nazionale Galileo (TNG). Data cover a significant fraction of the cluster and the Color Magnitude Diagram (CMD) ranges from the Tip of the Red Giant Branch down to the Main Sequence Turn-Off region. By using the K-band Period-Luminosity-Metallicity relation (PLZK) of RR Lyrae stars, we supply a new estimate of NGC5904 distance, i.e. $(m - M)_0 = 14.39 \pm 0.10$.

Key words. (Galaxy:) globular clusters: individual (NGC5904) – stars: horizontal-branch stars: variables: other techniques: photometric

1. Introduction

Galactic Globular Clusters (GGCs) are fundamental objects for several astrophysical topics, ranging from the stellar evolution models, to the dynamics of the Galactic Halo and Bulge. A key feature of the GGCs is that they often host RR Lyrae type variable stars (RRLs), which are fundamental distance indicators for old stellar populations. They are bright enough to be detected at moderately large distances and they are widely used as distance indicators, since their mean V-magnitude is almost constant. In particular their mean V-magnitude is calibrated as a linear function of their metal abundance [Fe/H], but this calibration is still hampered by several theoretical and observational uncertainties (see e.g. Bono et al. 2003). These problems can be partially overcome in the K-band, where RR Lyrae stars do follow (Longmore, Fernley & Jameson 1986) a well defined Period-Luminosity relation (PLK). When accounting for the effects of the metallicity, this relation turns into a Period-Luminosity-Metallicity relation (PLZK). This relation shows several advantages when compared to the optical distance indicator: from the theoretical side the PLZK relation is only minimally affected by evolutionary effects and its intrinsic spread is of the order of 0.03 mag (Bono et al. 2001, 2003). From the observa-

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tional point of view, K-band magnitudes are only minimally affected by reddening effects and the light curves have low amplitudes, allowing us to estimate the mean magnitude even with few observations. Moreover, empirical templates (Jones, Carney & Fulbright 1996) can be adopted to improve the estimate of the mean magnitude even when a single observation is available. Another key feature is that theoretical models show only a mild dependence of the PLZK relation on the bolometric luminosity at fixed pulsator mass, more than a factor two less than V-band magnitudes. Moreover, at fixed luminosity level, the non-negligible uncertainty on the pulsator mass can be constrained by evolutionary models, if the metallicity is known (Bono et al. 2003). This means that the PLZK relation can be effectively used for field RR Lyrae stars, for which no information is available about their evolutionary status. However, available PLZK calibrations do not agree on the dependence on the metallicity, with slopes ranging from 0.08 (Sollima et al. 2006) to 0.23 (Bono et al. 2003) mag/dex. Moreover, available empirical slopes computed for individual clusters, show a non negligible scatter, ranging from ~ -1.7 (IC4499) to ~ -2.9 (M55), as shown in Sollima et al. (2006). To adress these problems, we started a large observational project, aimed at gaining homogeneous and accurate photometry of a GGCs sample, covering a wide range of metallicities. In the present work we show our preliminary results for the Galactic globular cluster NGC5904 (M5).

2. Data analysis

We collected J and K images in six different runs from February 2001 to March 2002 with SOFI@NTT/ESO and two runs from May 2005 to July 2005 with NICS@TNG. Since the cluster is moderately extended, for each telescope two different pointings were adopted, one mapping the cluster in the North-South direction (SOFI) and the other in the East-West direction (NICS), covering two strips of about 5×5 arcmin^2 in both directions. Raw frames were corrected for flat field, bias and bad pixel mask with standard procedures, and the atmospheric contribution was subtracted with a two-step subtraction technique. Photometric reduction on the 96 J and 143 K useful frames was performed with DAOPHOTII/ALLFRAME packages (Stetson 1994). On average we have seven epochs for each variable. Absolute zero-points were obtained in the LCO system (Persson et al. 1998) by observing several standards during a photometric night.

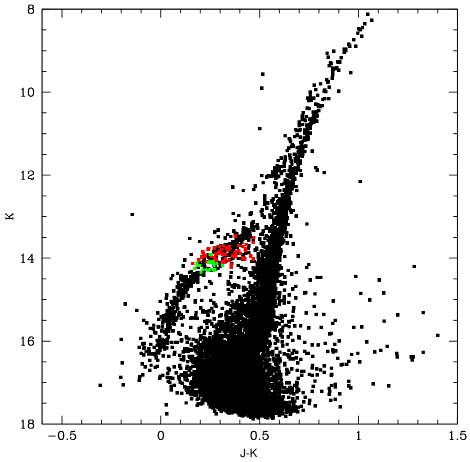

Fig. 1. CMD obtained from the whole data set. ALLFRAME mean magnitudes are plotted. We detected $\sim$ 30000 stars. Figure only shows stars with DAOPHOT parameters sharpness (sh) and χ (that are diagnostics of the goodness of the photometry) in the range $1 < sh < 1$ and $\chi < 0.6$, respectively. Detected RR Lyrae stars are overplotted in red (RR_{ab}) and green (RR_c).

3. Results

Figure 1 shows the Color-Magnitude diagram (CMD), obtained from the photometry of $\sim$ 30000 stars in M5. A glance at the CMD shows the distinction between the RGB and AGB sequences.

We used 77 RR Lyrae stars to investigate the PLK relation in M5. K-band pulsational parameters (amplitudes and mean magnitudes) of the detected RR Lyrae stars were obtained by fitting light curves with the templates by Jones et al. (1996). In Fig. 2 we show two K light

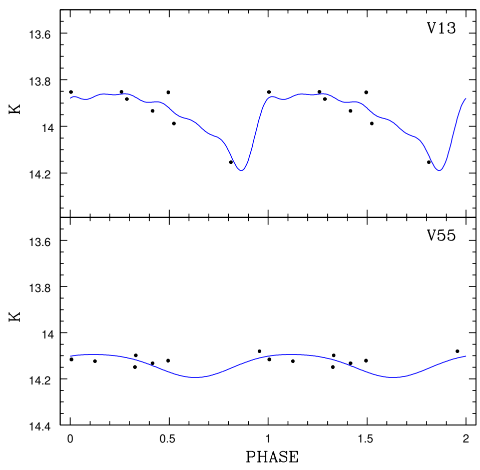

Fig. 2. Light curves for the M5 RR Lyrae stars V55 (lower panel) and V13 (upper panel). Observations were fitted with templates by Jones et al. (1996) (solid black line).

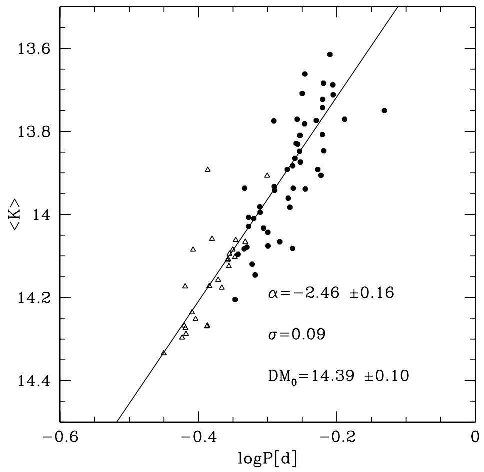

Fig. 3. Observed PLK relation for the M5. Filled circles and triangles show fundamental and fundamentalized pulsators, respectively. The solid blue line marks the theoretical prediction from Bono et al. (2001) for the derived distance modulus.

curves for one RR_{ab} (upper panel) and one RR_c (bottom panel), respectively.

Fig. 3 shows mean K-band magnitudes of the detected variables as a function of the period (empirical PLK relation). First overtone pulsators (filled triangles in the figure) were *fundamentalized*, i.e. we added 0.127 to their $\log P$, to use the same PLK relation for fundamental and first overtone pulsators (filled circles in the figure). The observed slope is $\alpha = -2.46 \pm 0.16$. This value is within 1σ consistent with the slope found by Sollima et al. (2006), that is −2.27. By adopting the theoretical calibration of Bono et al. (2001) ($M_K = -2.071 * (\log P + 0.30) + 0.167 * (\log Z) + 0.139$) and a color excess of $E(B-V) = 0.03$ mag (Harris 1996), we get the true distance is $(m-M)_0 = 14.39 \pm 0.10$, in agreement with the previous PLK-based estimate (Sollima et al. 2006), and with the optical-based estimates available in the literature (e.g. Di Criscienzo, Marconi & Caputo 2004). Interestingly enough, when we use our data with the calibration given by Sollima et al. (2006) ($M_K = -2.38 \log P_F + 0.09[Fe/H] - 1.04$), and with the calibration obtained by Cassisi et al. (2004) on the basis of HB models ($M_K = -2.34 \log P_F - 0.394$), we get the true distance moduli $(m-M)_0 = 14.38 \pm 0.10$ and $(m-M)_0 = 14.39 \pm 0.10$, respectively. In order to improve the precision of our results, a deeper analysis of our photometric catalog is currently in progress.

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