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Near-Infrared observations of cluster RR Lyrae in M92: preliminary results.

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Abstract. We present preliminary results on a long-term project aimed at obtaining accurate Near-Infrared photometry of a sizeable sample of RR Lyrae variables in galactic globular clusters (GGCs). The first results obtained for the variables in the cluster M92 are presented and briefly discussed. On the basis of a still preliminary photometric analysis, we obtained accurate and well-sampled RR Lyrae variable light curves from which all relevant pulsational parameters are derived. We perform a comparison between the estimated slopes of the Period - NIR Luminosity relations and both theoretical and empirical predictions. On the basis of these preliminary results we show the reliability of the current observational project.

Key words. Globular clusters: general – Stars: distances – Stars: variables: other –

1. Introduction

The traditional distance ladder for Population II stellar systems is the magnitude of RR Lyrae variables. For such reason, several observational and theoretical investigations have been devoted to such class of variables (Bono, Castellani & Marconi 2000, Clement et al. 2001). Nevertheless, RR Lyrae stars are still the crossroad of many unsolved astrophysical problems.

One of the most important problem is the lack of a general agreement concerning both the slope and the zero-point of the absolute magnitude - metallicity ($M_V(RR)-$[Fe/H]) relation (Caputo 1997, Cassisi et al. 2001, Benedict et al. 2002 and references therein). As a consequence, we are still dealing with the well-known dichotomy between *short* and *long* distance scales. Some methods, like Baade-Wesselink and statistical parallaxes approaches applied to field RR Lyrae stars and direct measurements of field Horizontal Branch (HB) stars (Gratton 1998) provide strong support to the *short* distance scale. Whereas, the pulsational properties of cluster RR Lyrae

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stars (Sandage 1993), the main-sequence fitting to local subdwarfs (Gratton et al. 1997), the calibration of HB luminosity obtained by using the Cepheid distance modulus of the Large Magellanic Cloud (Walker 1992), and analysis based on double-mode RR Lyrae (Kovács 2000) support the *long* scale. The main reason for which we still lack a firm understanding of the 'true' dependence of the RR Lyrae luminosity on the metallicity is related to the existence of still too large uncertainties affecting both the cluster distances, reddenings and metallicity estimates.
In order to overcome these problems, it has been suggested the use of near-infrared (NIR) bands. In fact, the observations in NIR bands and in particular in the K-band show significant advantages when compared with optical bands, since they show:

- a smaller dependence on interstellar extinction;
- a smaller dependence on metallicity;

In addition, it has been clearly shown by Longmore et al. (1986, 1990) that it exists a well-defined Period - K band luminosity (PL_K) relation. By taking into account all these evidence, it appears clear that NIR observations of RR Lyrae variables might be can a very powerful tool for measuring distances within the Galaxy and within the Local Group galaxies.
Even if in recent times a large effort has been devoted to increase the observational database for cluster RR Lyrae variables with accurate NIR observations, the whole RR Lyrae sample in each cluster has not been investigated, and in many cases the sampling of the light curves is very poor (of the order of 4 phase points). With the aim of checking the reliability and accuracy of the PL_K relation as a suitable distance indicator and testing the reliability of recent theoretical results in this field, we have started a project devoted to significantly improve the current database of NIR observations of GGC RR Lyrae stars. As far as the selection of the cluster targets is concerned, we have chosen the clusters on the basis of the richness of their variable population and their metallicity in order to have a sizeable number of RR Lyrae that cover a wide metallicity range.

2. Observations and reductions

The observations presented here were collected using the AZT-24 1.1-m telescope of the Campo Imperatore (L'Aquila) observatory on the Gran Sasso Mountain. This telescope is equipped with a NIR detector (SWIRCAM) which is based on a chip Rockwell 256x256 pixels, each pixel corresponding to 1.04 arcmin on the sky. Each image is resulting from the composition of repeated series of 5 dithered sky-subtracted frames. The photometric measurements have been performed in the JHK bands with these typical time exposures: 5 min (J band), 8-10 min (H band), 10-12 min (K band). For each variable we have collected, on average, 15 phase points per filter. The stars were identified and then measured by using DAOPHOT and ALLFRAME packages (Stetson 1987, 1994). On the basis of the photometry we have been able to obtain reliable estimates of the main pulsational parameters such as amplitudes and mean magnitudes in the different NIR bands. Standards fields have been already collected but their analysis is still in progress, so present calibration is based on some local standards from Cohen et al. (1978).

3. The Period - NIR Luminosity relations

Present observations for the RR Lyrae in M92 allowed us to obtain accurate light curves in the different NIR photometric bands. Figure 1 shows the light curves in J and K bands for some selected variables. The behavior of the mean J and K magnitudes with the pulsational period for the RR Lyrae in M92 is shown in figure 2. By using these data we have determined the slopes of the PL_J and PL_K re-

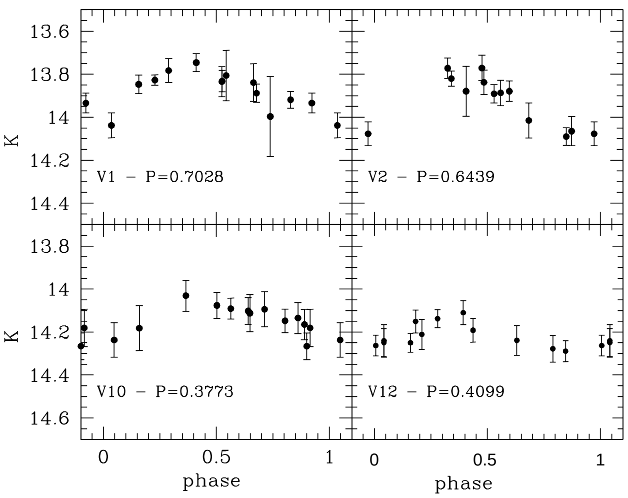

Fig. 1. K band light curves for a sample of RR Lyrae stars. ID number and periods reported are taken from Clement et al. (2001).

lations. The obtained values are reported in the same figure. It is worth remembering that recently Bono et al. (2002), on the basis of theoretical pulsation models, have derived the following PL_J and PL_K relations: $M_J = -1.491 \times \log P - 0.834$ and $M_K = -2.090 \times \log P - 1.225$ respectively (the zero point has been computed adopting [Fe/H]= -2.24). From an empirical point of view, there are several PL_K relations presently available. Those provided by Longmore et al. (1990, $M_K = -1.72 \times \log P - 0.737$) and by Liu & Janes (1990, $M_K = -2.26 \times \log P - 0.939$) correspond to the extreme published values for the slopes. From the comparison between present results and both theoretical and empirical predictions, we can derive the following conclusions:

- current slopes for both the PL_J and PL_K relations are, within the quoted uncertainties, in good agreement with updated theoretical expectations;
- the slope of the PL_K relation appears in satisfactory agreement with empirical evidences, even if our results provide a quite steeper slope in comparison with the result by Longmore et al. (1990);

By using the mean J and K magnitudes for our sample of variables and by adopting the theoretical PL_J and PL_K relations given by Bono et al. (2002) we have estimated the distance to the cluster M92 by obtaining $(m-M)_0 \approx 14.83 \pm 0.03$ mag (J band) and $(m-M)_0 \approx 14.76 \pm 0.05$ mag (K band). These values appear in fine agreement with recent indipendent estimates provided by Carretta et al. (2000).

4. Conclusions

Current results, even if still preliminary, clearly disclose that current project can be successfully carried out with the available equipment (AZT-24+ SWIRCAM array). Present results show the reliability of the PL relation in the NIR bands for measuring the distance to those galactic globular clusters with a sizeable population of RR Lyrae variables. When a more accurate photometric calibration will be available, and a larger sample of cluster RR Lyrae will be analized, we plan to investigate the following topics:

- to measure accurate relative distances for our target clusters;

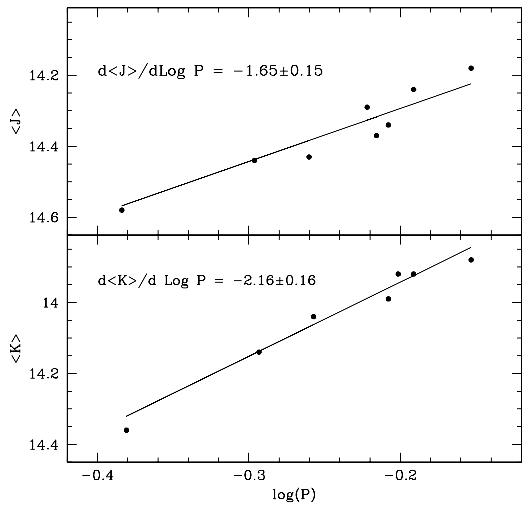

Fig. 2. Theoretical Log P - mean magnitudes relations (Bono et al. 2002) for both J (upper panel) and K band (lower panel) are overlapped to our data. Moreover the slopes obtained from a linear regression to the data are labelled in each panel. In the lower panel a variable (V6) is missing because of the large error affecting the photometry due to the crowding conditions.

- to provide independent estimates of their absolute distance;
- to compare pulsational theory and observations concerning the slope of the PL relation;
- to use the theoretical $\log P - (V - K)$ relation (Bono et al. 2002) in order to have insight into the intrinsic luminosity of Horizontal Branch stars.

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References

Benedict, G.F, et al. 2002, AJ, 119, 2866
Bono, G. et al. 2002, submitted to MNRAS
Bono, G., Castellani, V. & Marconi, M. 2000, ApJ, 529, 293
Caputo, F. 1997, MNRAS, 284, 994
Carretta, E., Gratton, R. G., Clementini, G., Fusi Pecci, F., 2000, ApJ, 533, 215
Cassisi, S., De Santis, R. & Piersimoni, A. 2001, MNRAS, 326, 342
Clement, C. et al., 2001, AJ, 122, 2587
Cohen, J. G., Frogel, J. A. & Persson, S.E., 1978, ApJ, 222, 165
Kovàcs, G., A&A, 2000, 363, L1
Gratton, R., Fusi Pecci, F., Carretta, E., Clementini, G., Corsi, C. E., Lattanzi, M. 1997, ApJ, 491, 749
Liu, T. & Janes, K.A., 1990, ApJ, 354, 273
Longmore, A. J., Fernley, J.A., Jameson R.F., 1986, MNRAS, 221, 589
Longmore, A.J., Dixon, R., Skillen, I., Jameson, R. F., Fernley, J. A., 1990, MNRAS, 247, 684
Sandage, A., 1993, AJ, 106, 687
Stetson, P.B., 1987, PASP, 99, 191
Stetson, P.B., 1994, PASP, 106, 250
Walker A.R., 1992, ApJL 390, 81