MAD Science Demonstration Proposal

Nailing down the second parameter problem in NGC 288 and NGC 362

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Abstract:

We plan to collect accurate and deep J, K-band photometry of the Galactic Globular Clusters (GGCs) NGC 362 and NGC 288. The new NIR data together with optical data will provide the unique opportunity to investigate the stellar content of these clusters and to constrain their age with an accuracy of the order of 1 Gyr. This will allow us to assess whether the age is the culprit for the second parameter problem.

Scientific Case:

The GCs NGC 288 and NGC 362 form one of the best pair to explore the so-called second parameter problem. Although these GCs present very similar chemical abundances, in terms of both iron and α elements (Shetrone & Keane, 2000, AJ, 119, 840), the morphology of their Horizontal Branch (HB) differs significantly. The age has been one of the most investigated possible culprit to solve the second parameter problem, but still the debate is open. In the case of NGC 288 and NGC 362, different investigations indicate that they present an age difference, and in particular that NGC 288 is 2±1 Gyr older (Bellazzini et al, 2001, AJ, 122, 2569, Catelan et al., 2001, AJ, 122, 3171). However, the overall picture is still not clear, and other structural parameters seem to play a role (the different concentration of the two clusters, Buonanno et al. 1997; Catelan et 2001, Castellani et al. 2006).

Our group has already been involved in the reduction of J, Ks-band data collected with MAD. Fig. 2 shows the optical-NIR CMD of ω Cen based on data collected with two different MAD pointings. To our knowledge this is the deepest optical-NIR diagram ever collected for a GC. The scientific impact of the new NIR data will be discussed in a forthcoming paper (Calamida et al. 2007, in preparation). Our group has already reduced multiband optical ground-based (see Fig. 1) for these clusters and we are reducing deep ACS@HST data.

Immediate objectives

- The new data collected with MAD will allow us to derive the deepest NIR CMD ever obtain for the two clusters;
- We plan to perform accurate estimate of the relative ages of NGC 288 and NGC 362. The HB in the (V,$V-K$) plane follows a well defined slope. This will permit us to shift and align the CMD of the two clusters. We then plan to apply both the horizontal and vertical method to estimate the relative ages;
- The sizable sample of RR Lyrae stars in NGC 362 (45) will allow us to estimate the absolute distance with an accuracy better than 0.1 (Del Principe et al. 2006, ApJ, 652, 362), and in turn to estimate the cluster absolute age with an accuracy of the order of 1 Gyr. **Note that the color-age derivative based on an optical-NIR colors $\Delta(B-K)/\Delta t$ is, at fixed metallicity, more than a factor of two larger than those based on optical colors $\Delta(B-V)/\Delta t$.**
- The stronger sensitivity of the $B-K$ color to the effective temperature will allow us to constrain the fraction of binaries located above the canonical MS and to constrain the accuracy of current color-temperature relations.

Targets and integration time

Target	RA	DEC	Filter	Magnitudes	Total integration **time** (sec)	Field (arcmin)
NGC 288	00 52 47.0	-26 35 24	J, Ks	$10 - 21$	2×6240	1×1
NGC 362	01 03 54.0	-70 50 24	J, Ks	$10 - 21$	2×6240	1×1

Guide stars list and positions

The three guide stars we selected inside a box of 2 arcmin^2 in **NGC 288** are: 1)$V = 12.987$, $RA = 00 : 53 : 01$, $\delta = -26 : 36 : 06$ 2)$V = 13.209$, $RA = 00 : 52 : 58$, $\delta = -26 : 36 : 05$ 3)$V = 13.233$, $RA = 00 : 52 : 52$, $\delta = -26 : 35 : 20$, while for **NGC 362** they are: 1)$V = 11.812$, $RA = 01 : 03 : 13$, $\delta = -70 : 50 : 59$ 2)$V = 12.301$, $RA = 01 : 03 : 12$, $\delta = -70 : 50 : 38$ 3)$V = 12.393$, $RA = 01 : 03 : 20$, $\delta = -70 : 50 : 55$ **Note that the central density of NGC 288 ($\log \rho_v = 1.83 L_\odot pc^{-3}$) is three orders of magnitude smaller than in NGC 362 ($\log \rho_v = 4.7 L_\odot pc^{-3}$). For the former cluster, we included guide stars with $V \sim 13.1 \pm 0.1$, since we do not require the optimal instrumental performance.**

Time Justification:

We plan to collect NIR data in two different pointings located across the cluster centres. For each pointing we plan to collect J, Ks-band data with a limiting magnitude of $J = K \approx 20.5$ and a $S/N \approx 10$. According to the quality of the data collected in Omega Cen the exposure time per field are:

t(Ks)= 5 **(images)** $\times$ [10×24 **(target)** + 10×24 **(sky)**] + **1200 (acquisition)=3600 sec**

t(J) = 3 **(images)** $\times$ [10×24 **(target)** + 10×24 **(sky)**] + **1200 (acquisition)=2640 sec**

The total time per field is 1.73 h, thus the total time we request for the two clusters is $\mathbf{t_{tot} = 6.9h}$

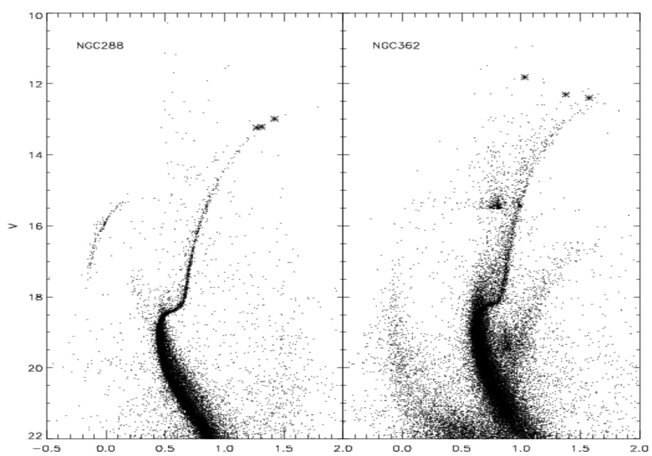

Figure 1: Top - $V, B - V$ Color-Magnitude Diagram of NGC 288 (left) and NGC 362 (right) based on our ground-based photometry. The astrisks mark the position of the guide stars.

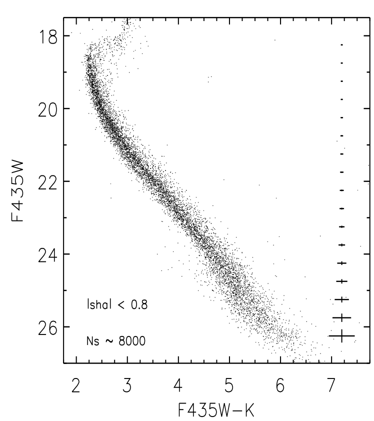

Figure 2: Optical-NIR Color-Magnitude-Diagrams of Omega Cen. The $B-$band data were collected with ACS@HST, while K-data have been collected in two different pointings with MAD@VLT. The K-band limiting magnitude is $K \sim 20.5 - 21$.