MAD Science Demonstration Proposal

Title: Deep into the lower main sequence of the globular cluster NGC 3201

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Abstract:
We plan to collect accurate and deep J, K-band photometry of the GC NGC 3201. The new NIR data together with optical data will provide the unique opportunity to investigate the stellar content of this cluster in the lower main sequence and to investigate the luminosity function down to very low-mass regime. We also plan to constrain with an accuracy of the order of 1 Gyr the cluster age and to investigate the intimate nature of some X-ray sources recently detected in this cluster.

Scientific Case:
The Galactic Globular Cluster (GGC) NGC 3201 is located at relatively short distance ($\mu = 13.32 \pm 0.06$, Piersimoni et al. 2002, AJ, 124, 1528) and presents a low central density and a large tidal radius ($\log \rho_v = 2.69 L_{\odot} pc^{-3}$, $r_t \sim 28$ arcmin, Harris 1996, AJ, 112, 1487). Moreover, NGC 3201 presents a highly-retrograde orbit (van den Bergh 1993), thus suggesting that it is not a typical member of the halo GC population. It has been associated to different Galactic stellar streams, but these associations were ruled out by Casetti-Dinescu et al. (2007, AJ, 134, 195) on the basis of its distance on the Galactic plane. The main drawbacks of NGC 3201 are that it is affected by field contamination, presents a relatively high reddening [E(B-V) 0.25-0.30], and is also affected by differential reddening (see Fig. 1). The observational scenario concerning NGC 3201 was recently enriched by the detection of a large number of X-ray sources (Webb et al. 2006, A&A, 445, 155) and their radial distribution indicates that this cluster was perturbed by the Galactic field. The occurrence of these objects in a GC with very low central density is puzzling, since they are considered the aftermath of stellar encounters.

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 data (see Fig. 1) and we are reducing deep ACS@HST data.

Immediate objectives

- The $K, J-K$ CMD will be adopted to provide accurate star counts of both evolved and MS stars that are marginally affected by differential reddening. We also plan to investigate the luminosity function of MS stars down to the very low-mass regime. **Note that low-temperature, very low-mass stars are significantly brighter in the NIR bands than in the optical bands.**

- By using the large sample of RR Lyrae stars (77) we plan 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 age with an accuracy of the order of 1 Gyr. **Note that the color-age derivative $\mathbf{\Delta(B-K)/\Delta t}$ is, at fixed metallicity, more than a factor of two larger than $\mathbf{\Delta(B-V)/\Delta t}$.**

- The deep J, K photometry will allow us to investigate whether some of the X-ray sources detected in this cluster show NIR excess, and time variability, and in turn, to constrain their nature (Cataclysmic variables, active binaries, millisecond pulsars).

- 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 3201	10 17 36.8	-46 24 40	J, Ks	$10-21$	3×6240	1×1

Guide stars list and positions

The three guide stars we selected inside a box of 2 arcmin^2 are: 1)$V = 11.768$, $RA = 10:17:25$, $\delta = -46:26:21$ 2)$V = 11.779$, $RA = 10:17:23$, $\delta = -46:26:44$ 3)$V = 12.422$, $RA = 10:17:16$, $\delta = -46:25:29$. Across the cluster centre there are a few other stars with $V \leq 13$.

Time Justification:

We plan to collect NIR data in three different pointings located across the cluster centre. For each pointing we plan to collect J, Ks-band data with a limiting magnitude of $J = K \approx 21$ 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 is $\mathbf{t_{tot} = 5.2h}$

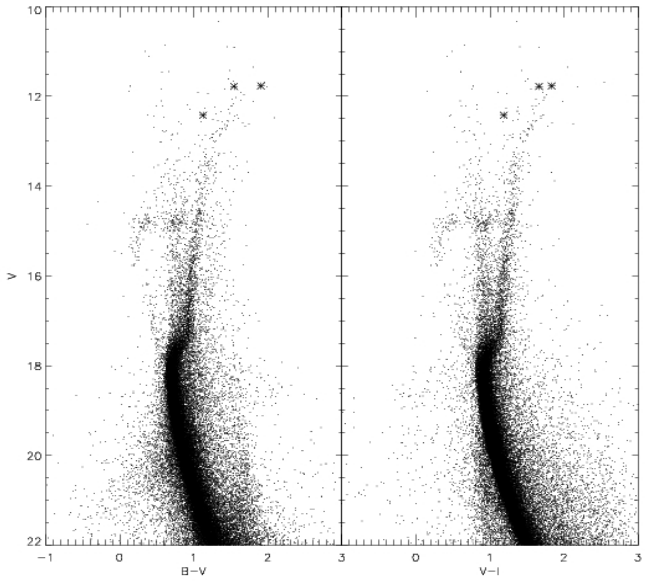

Figure 1: Color-Magnitude Diagrams of NGC 3201 in $V, B-V$ (left) and in $V, V-I$ (right) based on our ground-based photometry. The asterisks mark the position of the guide stars.

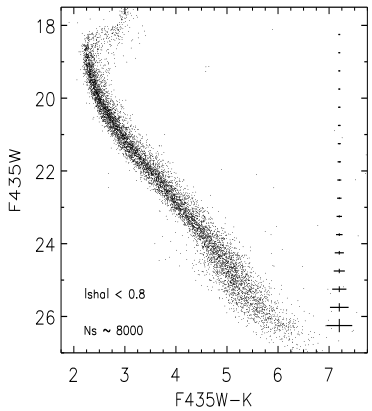

Figure 2: Optical-NIR Color-Magnitude-Diagrams of Omega Cen. The $B-$band data were collected with ACS@HST, while K-data have been collected in two different pointings with MAD@VLT. The K-band limiting magnitude is $K \sim 20.5 - 21$.