MAD Science Demonstration Proposal

Title: The age of a metal rich and a moderately metal poor globular clusters in the Galactic bulge

Investigators	Institute	EMAIL
Ortolani S.	Univ. of Padova (Italy)	sergio.ortolani@unipd.it
Bica E.	Univ. do Rio Grande do Sul (Brazil)	
Barbuy B.	Univ. de So Paulo, So Paulo (Brazil)	
Momany Y.	INAF: Padova Astro. Obs. (Italy)	

Abstract: We propose to obtain deep JK MAD observations of the globular clusters HP1 and NGC6342, located in the Galactic bulge. The two clusters allow us to probe simultaneously the metal poor and the metal rich components of the bulge, where the metal poor globular clusters are expected to be the *oldest* in the Galaxy. Our goal is to derive accurate age estimates of the 2 clusters (via the detection of the old main sequence turnoffs) and infer any age difference (if any) between the 2 clusters. This would ultimately impact on our understanding of the time-scale of bulge formation. Given the high stellar density and reddening (as well as differential reddening) the 2 clusters are best studied by means of near infrared JK MAD imaging.

Scientific Case: With respect to that of other galaxies, the bulge of our Milky Way is studied in great detail. In terms of its stellar population content it is old; very close to that of typical elliptical galaxies. It remains however that the physical processes contributing to the bulge formation are still matter of debate. In particular, it is not clear the fraction of population generated during the early phases of collapse versus the later accretion episodes and interactions (with the bar, spiral arms and other disk derived interaction phenomena). Direct measurements of the ages, from colour-magnitude diagrams of fields and globular clusters in the bulge are not easy due to the high stellar densities and contamination from the disk population. Within somewhat large uncertainties they give an old average age, comparable to the halo (Ortolani et al., 1995, *Nature, 377, 701*). A further support to this view comes, indirectly, from the chemical analysis of high resolution spectroscopy. However this conclusion is still matter of controversy given, for example, the presence of bright IR/OH stars and a very young component in the inner part of the bulge where the so called "nuclear population" is located.

Moreover, it is not clear if there is a distinction (or a continuity) between an earlier, more metal poor population, and a later one with almost solar metallicity. In order to give an answer to this specific question we propose to take advantage of the great performances of MAD at VLT in terms of resolution to observe two selected bulge globular clusters characterized to be near to the two extremes of the metallicity distribution of the bulge globular clusters, NGC6342, with a metallicity of about [Fe/H]$= -0.60$ (Origlia and Rich, 2004, *MNRAS, 356, 1276*) and one relatively metal poor cluster; HP1. The latter is the best target for a metal poor cluster in the bulge because it is concentrated and well populated. We obtained detailed metal abundances from high resolution spectra of two stars in HP1 using VLT-UVES and VLT-FLAMES (Barbuy et al., 2006, *A&A, 449, 349*) and derived a metallicity of [Fe/H]$\simeq -1.0$ and an excess of the alpha-elements silicon and oxygen of $+0.3$. We already observed HP1 in the V and I bands, with NTT, under excellent seeing conditions ($0.''4 - 0.''5$). We detected a blue horizontal branch, typical of intermediate or metal poor clusters, but not the main sequence turnoff. Only in the near infrared and with a very high resolution it is possible to read off the problems of differential reddening and crowding and obtain a high photometric accuracy at the main sequence turnoff expected, for both the clusters, around $J \simeq 18.25$.

Time Justification: We plan on repeating our first MAD observation strategy (Momany et al. submitted). We therefore plan to obtain a $2'$ diameter field of view of the two clusters using the $2\times2+1$ mosaic. For each of the J and K filters, the total integration time of each exposure will be

300sec. (divided in DITs of 10 sec. and NDIT of 30). This strategy will allow us to reach faint K magnitudes of ~ 19.0 at a photometric completeness level of $\sim 50\%$ and an estimated photometric error of only ~ 0.08. This means that we will reach $\sim 1.0-1.5$ magnitudes below the turnoff level of the 2 clusters. This will reflect on an accurate detection of the turnoff levels and ages of the 2 clusters. The above strategy imply a total exposure time of ~ 25 min. for the $2\times2+1$ scientific images, in one filter. Thus, ~ 50 min. for JK imaging for each cluster. Accounting for the 20 min. for aquisition and 4 minutes for the grid dithering mode (for both the Object and the Sky pointings), we estimate that each of our cluster will require ~ 2.7 hours.

We therefore make a final request for 2.7×2 hours.

Targets and integration time:

Target	RA	DEC	Filter	Magnitudes	**Total integration time** (sec)	**Field** (arcmin)
HP1	17 31 05	−29 58 54	J	J=12-20	$10s\times30=300$	2
HP1	17 31 05	−29 58 54	Ks	Ks=11-19	$10s\times30=300$	2
NGC6342	17 21 09.233	−19 35 14.81	J	J=12-20	$10s\times30=300$	2
NGC6342	17 21 09.233	−19 35 14.81	Ks	Ks=11-19	$10s\times30=300$	2

GSC2 guide stars list and positions with respect to the reported field center:

Target	$\mathbf{RA}''_{rel}$	$\mathbf{DEC}''_{rel}$	**V Mag**
GSC1-HP1	+42.5	+31.2	11.81
GSC2-HP1	−44.2	+26.8	12.01
GSC3-HP1	+13.6	−25.5	11.71
GSC1-NGC6342	+13.2	+8.5	12.06
GSC2-NGC6342	−10.2	−8.9	12.13
GSC3-NGC6342	+11.1	−36.2	12.76

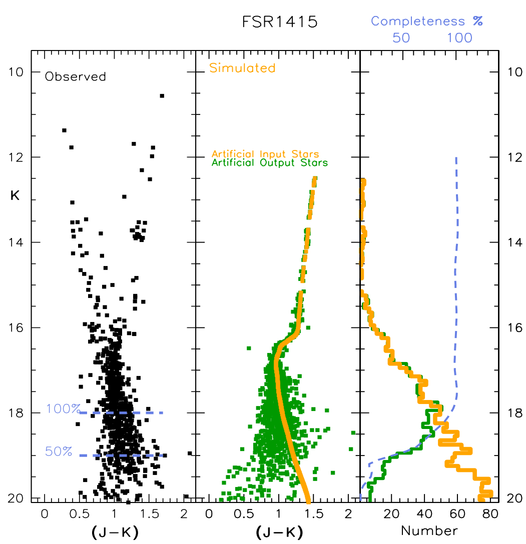

Figure 1: Left panel shows the observed MAD diagram for FSR 1415 (Momany et al.), while the middle panel displays the simulated and recovered artificial stars. The right panel compares the luminosity function of the input/output artificial stars whereas the light dashed line shows the computed K completeness level.