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First results on resolved stellar population in three Galactic globular cluster from LBC@LBT imaging

G. Beccari[1], L. Pulone[3] F.R. Ferraro[2], B. Lanzoni[2], F. Fusi Pecci[1], R.T. Rood[4], E. Giallongo[3], R. Ragazzoni[5], A. Grazian[3], A. Baruffolo[5], C. De Santis[3], E. Diolaiti[1], A. Di Paola[3], J. Farinato[5], A. Fontana[3], S. Gallozzi[3], F. Gasparo[6], G. Gentile[5], R. Green[7], J. Hill[7], O. Kuhn[7], N. Menci[3], F. Pasian[6], F. Pedichini[3], R. Smareglia[6], R. Speziali[3], V. Testa[3], D. Thompson[7], E. Vernet[8], and R.M. Wagner[7]

[1] Dipartimento di Astronomia, Università di Bologna, via Ranzani 1, I-40127 Bologna, Italy, e-mail: giacomo.beccari@oabo.inaf.it
[2] Università di Bologna, Via Ranzani 1, I-40127, Bologna, Italy
[3] INAF, Osservatorio Astronomico di Roma, Via Frascati 33, I-00040, Monte Porzio, Italy
[4] Astronomy University of Virginia, PO Box 400325, Charlottesville, VA 22904
[5] INAF, Osservatorio Astronomico di Padova, Vicolo dell'Osservatorio 5, I 35122 Padova, Italy
[6] INAF, Osservatorio Astronomico di Trieste, Via G.B. Tiepolo 11, I-34131 Trieste, Italy
[7] Large Binocular Telescope Observatory, University of Arizona, 933 N. Cherry Ave., Tucson, AZ 85721-0065
[8] INAF, Osservatorio Astronomico di Arcetri, Largo E. Fermi 5, I-50125, Firenze, Italy

Abstract. We present first results on resolved stellar population by wide-field imaging obtained at the Large Binocular Telescope. The data presented were obtained through the blue channel of the Large Binocular Camera, during the commissioning and the science demonstration time of the camera. The scientific cases presented are deep multiband observations of three galactic globular clusters namely NGC5053 (M53), NGC6341 (M92) and NGC5466. The colour-magnitude diagrams of these clusters, spanning all the canonical sequences from the tip of the red giant brunch down to 4 magnitudes below the main sequence Turn Off, combined with high resolution ACS@HST archive images of the central region of the clusters, allow us to study the population radial distribution. In particular the population of blue stragglers stars in M53 and NGC5466 was found to have a bimodal radial distribution. Moreover we determined the binary frequency in the outer regions ($r > 200''$) of M53, finding that about 14% of the stars in these regions are in binary systems.

Key words. Globular cluster: M53, NGC5466, M92 – Stars: blue stragglers, binary systems

1. Introduction

Globular Clusters (GCs) are ideal astrophysical laboratories for studying the evolution of single stars, as well as of binary systems. In particular, the evolution and the dynamical interactions of binary systems in high-density environments can generate objects (like Blue Straggler Stars, X-ray binaries, millisecond

Send offprint requests to: G. Beccari

pulsars, etc.) that cannot be explained by standard stellar evolution. In this respect the most common exotic objects are the so-called Blue Straggler Stars (BSSs). BSSs are core-hydrogen burning stars with masses larger than normal cluster stars, and their origin is still a puzzle. In recent years we have determined the BSS radial distribution in a number of GCs (see references in Lanzoni et al. 2007, hereafter L07), finding that it is bimodal (i.e., with a peak in the centre and an upturn in the external regions) in at least 8 cases. By supporting these observations with accurate dynamical simulations, we have demonstrated that $\sim$20-40% of the entire BSS population in the "bimodal GCs" must be generated by mass-transfer (MT) between binary companions (MT-BSS), most of them still populating the cluster outskirts. A negligible fraction of MT-BSSs is instead required in the case of GCs with non-bimodal radial distribution. Here we study the BSS and binary populations in three GCs namely NGC5024 (M53), NGC6341 (M92) and NGC5466, taking advantage of deep wide field imaging from the blue channel of the Large Binocular Camera (LBC-Blue) mounted at Large Binocular Telescope (LBT).

2. Observations and data reduction

The photometric data presented here consist of deep multi-filter (U, B, V and r depending on the observed cluster; see table 1) wide-field images, secured during the Science Demonstration Time (SDT) of LBC-Blue (Ragazzoni et al. 2006; Giallongo et al. 2007) mounted on the LBT, sited at Mount Graham, Arizona (Hill et al. 2006). The LBC is a wide-field imager which provides an effective $23' \times 23'$ field of view, sampled at 0.224 arcsec/pixel over four chips of 2048×4608 pixels each. LBC-Blue is optimised for the UV–blue wavelengths, from 320 to 500 nm, and is equipped with the U, B, V, g and r filters.

The pre-reduction and the photometry of the whole dataset was performed using the procedure described in Beccari et al. (2008a, hereafter B08a). All the raw LBC images were corrected for bias and flat field, and the overscan region was trimmed using a pipeline from LBC-team at Rome Astronomical Observatory[1] specifically developed for LBC image pre-reduction. The source detection and relative photometry was performed independently on each filter image of each dataset, using the PSF-fitting code DoPHOT (Schechter, Mateo & Saha 1993).

Table 1. Photometric data

Filter	# of images	Exp. Time [sec]	Cluster
U	2	500	M53
–	1	20	M53
B	2	300	M53
–	1	10	M53
V	8	300	M53
–	1	10	M53
U	9	500	M92
–	1	20	M92
B	9	300	M92
–	1	10	M92
r	8	300	M92
–	1	10	M92
B	7	90	NGC5466
V	7	60	NGC5466
r	7	60	NGC5466

3. The *M53* and *M92* sample

In Fig. 1 we show the CMD of the LBC-Blue (left panel) properly combined with a ACS catalogue sampling the core region (right panel; see B08a). The selected BSS and HB stars (assumed as reference population) are marked with open circles and triangles, respectively. Details on selection criteria are described in B08a. According to L07, we divided our catalogue in concentric annuli centred on the cluster centre (from Harris et al. 1996). Then we counted the number of BSSs, HBs and derived them ratio in each annulus. M53 shows a bimodal radial distribution of BSSs i.e. with a high frequency in the inner and outer regions, but a distinct dip in the intermediate region (see

[1] http://lbc.oa-roma.inaf.it/

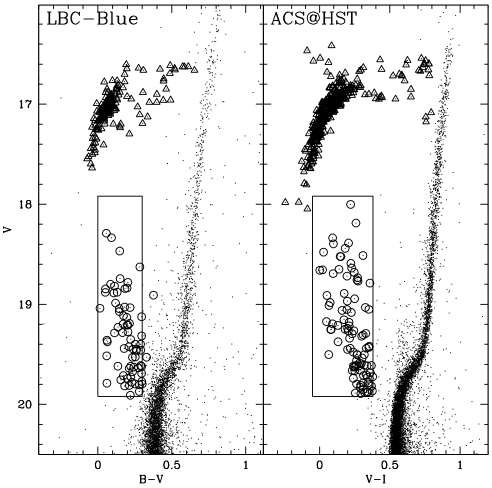

Fig. 1. CMDs obtained from LBC-Blue (left panel) and ACS@HST (right panel) data.

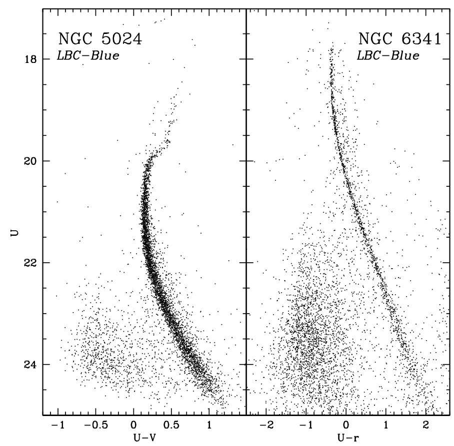

Fig. 2. (U, $U - V$; left panel) and (U, $U - V$; right panel) CMDs of NGC5024 (M53) and NGC6341 (M92) respectively obtained through the reduction of deep LBC-Blue images.

Fig. 7 in B08a). Notice that, taking advantage of the wide field capabilities of LBC-Blue, we derived the BSS radial distribution, up to $r \simeq 14.2'$ from the centre. Dynamical simulations based on an updated version of the code described by Sigurdsson & Phinney (1995), have been successfully used to properly reproduce the BSS radial distribution (see Mapelli et al. 2006, L07). The simulations demonstrate that in GCs showing a BSS bimodal radial distribution, the observed central peak is mainly due to collisional BSS (COL-BSSs) formed in the core and/or MT-BSSs sunk to the centre because of dynamical friction effects, while the *external* rising branch should be made of MT-BSSs evolving in isolation in the cluster outskirts. The frequency of binary system is a important ingredient in a proper calculation of dynamical models in crowded environments like GCs. With the intent of studying the binary frequency in the external of M53 we acquired a series of deep U, B and V images of the cluster. Here we present the first very preliminary photometry of an external chip (namely # 3) of the camera mosaic. Figure 2 (left panel) shows the CMD in the (U, $U - V$) plane. This is the deepest CMDs ever published for this cluster. With a 300s V and 500s U exposure we reached magnitude $U \simeq 24.5$ with a S/N ~ 5 according with the expected performances of the "telescope plus camera" system. The CMD plotted in left panel of Fig. 2 shows a very well defined MS with a secondary MS (SMS) clearly visible. This is likely generated by a binary population. In order to perform a preliminary estimate of the binary fraction ξ in M53 we used the same procedure described by Sollima et al. (2007). Very quickly, we performed completeness experiments on the images and, using the simulated catalogue, we generated a simulated binary population with a distribution $f(q)$. The value of ξ derives from the comparison between the colour distribution of simulated stars and that in the observed CMD. We assumed a distribution constructed by extracting random pairs of stars using the initial mass function of De Marchi et al. (2005). Using this method we derive a best value in percentage of binary fraction of 14% in the external region of M53. We are going to apply the same method in order to study the binary stars in the GC M92. In Fig. 2 (right panel), we show the CMD obtained through the analysis of the deep M92 data-set. The analysis of the binary fraction, performed using the same method previously described, is in preparation and will be presented in forth-

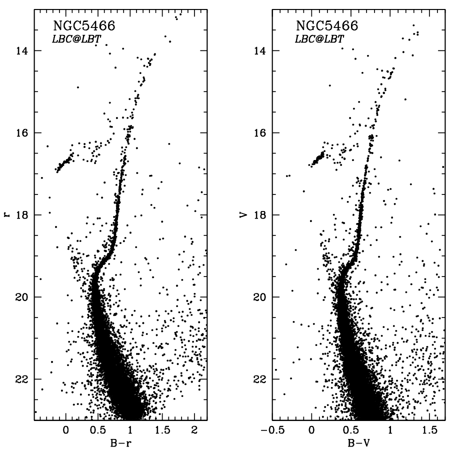

Fig. 3. (V, $B-V$; left panel) and (r, $B-r$; right panel) CMDs of NGC5466.

coming paper (Beccari et al. 2008b, in preparation)

4. The *NGC5466* sample

The images for this cluster were taken with a seeing of $\sim$ 0.6 arcsec. The extremely good weather conditions allowed us to acquire very high quality images. Figure 3 shows the $V, B-V$ (left panel) and $r, B-r$ (right panel) CMDs. The photometric catalogue was obtained using the same pre-reduction and reduction strategy described in Section 2. The photometric quality of the CMDs is quite impressive. All the evolutionary sequences are well defined from the tip down to 3 magnitudes below the turn Off. Again we used this catalogue to study the radial distribution of the BSS stars finding them to have a bimodal radial distribution. Further and detailed discussion concerning the photometry and BSS population of this cluster will be showed in a forthcoming paper (Beccari et al. 2008c, in preparation).

5. Conclusions

The results shown here contribute to the observational characterisation of BSSs in M53 and NGC5466. Moreover, we show once again the importance of an observational approach which combines the high resolution HST capabilities in the core-crowded regions and big telescope like LBT equipped with wide field instrumentation.

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