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Deep and extended multiband survey of the Galactic globular cluster M92

A. Di Cecco[1,2], G. Bono[2], M. Monelli[3], A. Calamida[2], M. Nonino[4], P.B. Stetson[5], R. Buonanno[1], F. Caputo[2], C.E. Corsi[2], I. Ferraro[2], G. Iannicola[2], and L. Pulone[2]

[1] Università di Roma Tor Vergata – via Della Ricerca Scientifica 1, 00133 Roma, Italy
[2] INAF – Osservatorio Astronomico di Roma, Via Frascati 33, 00040 Monte Porzio Catone, Roma, Italy
[3] IAC – Calle Via Lactea, E38200 La Laguna, Tenerife, Spain
[4] INAF – Osservatorio Astronomico di Trieste, Via Tiepolo 11, 34131 Trieste, Italy
[5] DAO – HIA, 5071 West Saanich Road, Victoria, BC V9E 2E7, Canada

Abstract. We present wide-field ground based photometry for the Galactic globular cluster M92. Data were collected in the SDSS bands (u', g', r', i', z') with the MegaCam@CFHT. We confirm the occurrence of cluster stars beyond the tidal radius. Moreover, we find that the ratio between the Horizontal Branch (HB) stars and Main Sequence (MS) stars across the turn-off region clearly decreases by a factor of two when moving from the centre to the outermost regions of the cluster.

Key words. globular clusters: general - globular clusters: M92

1. Introduction

Globular clusters (GCs) tipically host simple stellar populations, therefore they are the most suitable laboratories for testing stellar evolution theory. GCs also provide key information concerning the Galactic structure and dynamics. As predicted by Lee & Ostriker (1987), the Galactic gravitational field affects the GC morphology. Therefore, the outer regions of the GCs should show a stellar excess when compared with the profile predicted by the King model. We selected M92 ([Fe/H] = -2.28, Harris 1996) since it is one of the most popular template for old very metal-poor GCs. M92 is a deeply investigated GC and its intrinsic parameters are well-known. M92 position is far from the Galactic plane (l=68.34° b=34.86°, Harris 1996) and it presents low reddening (E(B-V) = 0.02, Harris 1996) with a marginal contamination by field stars. Moreover, M92 radial profiles based on the star counts of photographic plates (Testa et al. 2000) and of CCD mosaics (Lee et al. 2003) suggest the presence of extratidal stars.

2. Data and reduction strategy

The complete data sample consists of deep and shallow images collected in the 5 Sloan Digital Sky Survey (SDSS) bands (u', g', r', i', z') with the MegaCam@CFHT, for a total of 57 dithered exposures. MegaCam is the largest astronomical CCD mosaic built up-to-date, based on 36 (2048 x 4612 pixel) CCDs covering

Send offprint requests to: dicecco@roma2.infn.it

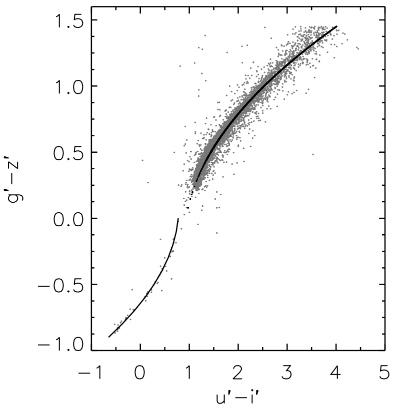

Fig. 1. Colour-colour diagram for the selected stars and fit with two fiducial lines.

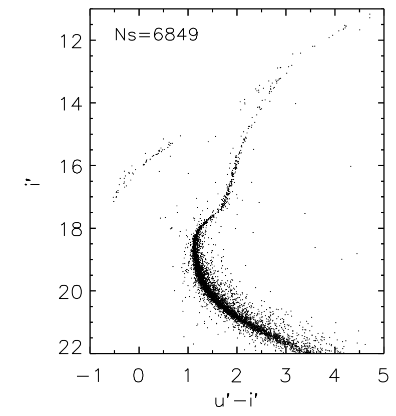

Fig. 2. Colour magnitude diagram for the selected stars.

a 1°×1° field-of-view and with a resolution of 0.18”/px (Boulade et al. 2003).We present ALLFRAME PSF photometry for 16 out of the 36 chips. Six chips cover the central region of the cluster up to 10’. Two chips are located across the tidal radius ($r_t = 15'$) and 8 chips are located beyond the tidal radius. Individual catalogs of the chips were rescaled to a common reference system using DAOMASTER. The final photometry was performed running ALLFRAME (Stetson 1987, 1994) simultaneously over the entire dataset. The calibration curves for the 5 bands were estimated using more than 1000 local standard stars from SDSS archive.

3. Results and discussion

In order to identify cluster and field star candidates we selected a fiducial cluster sequence of H burning (MS) and evolved evolutionary phases (HB, RGB). The template was selected in an annular area between 0.7′ and 5′ around the centre of M92 to overcome the crowding of the innermost regions and the possible field stars contamination in the outermost regions. We plotted this sample in the $(u' - i')$ vs $(g' - z')$ colour-colour plane, using the two colours which present the higher sensitivity to the effective temperature. We fit the template sequence with two fiducial lines: one for HB stars and another for the MS-RGB stars, as shown in Fig.1.The colour-magnitude diagram for the selected sample is shown in Fig.2. We defined 3 annular regions around the centre of the cluster: $0.3' < r < 4.3'$, $4.3' < r < 15'$ and $r > 15'$. Left panels of Fig.3 presents the colour-magnitude diagram of the three subsamples. For each annulus we considered candidate HB cluster stars the objects with $(u'-i')$ colour located within ±0.8 mag from the HB fiducial line and candidate MS-RGB cluster stars the objects with $(u' - i')$ colour located within ±0.5 mag from the MS-RGB fiducial line. The candidate cluster stars are shown in the middle panels of Fig.3. The other stars are considered as candidate field stars and are shown in the right panels of Fig.3. Data plotted in the last middle panel of this figure clearly indicate a presence of MS stars beyond the tidal radius.

In a second step, we calculated the ratio between HB and MS stars located within 0.2 mag across the turn off point ($M_{g'} \sim 18.7$) for 3 different colour-magnitude diagrams and for 3 different concentric regions: $1' < r < 1.5'$, $1.5' < r < 2.6'$ and $r > 2.6'$. Data listed in Table 1 show that the star count ratios HB/MS strongly decreases by a factor of two when moving from the innermost to the outermost regions of the cluster.

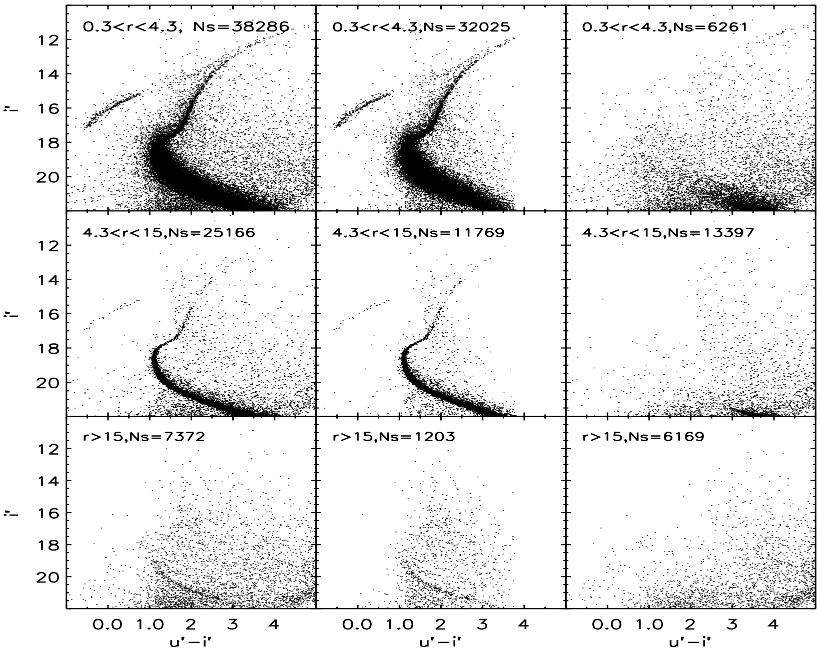

Fig. 3. Colour-magnitude diagrams for 3 different annular regions around M92 center. For each region the entire sample is plotted on the left panel, the candidate cluster stars are in the middle panel and field stars are on the right.

Table 1. Star count ratios between HB and MS stars for 3 different annuli and for 3 different colour-magnitude diagrams. The MS stars are located within 0.2 mag around the turn off region: $M_{g'} \sim 18.7$. The color ranges used to select MS stars are listed in the second column.

CMD	*MS*	$1' < r < 1.5'$	$1.5' < r < 2.6'$	$r > 2.6'$
$g', g' - i'$	0.1 – 0.5	0.37 ± 0.05	0.19 ± 0.02	0.21 ± 0.03
$g', g' - z'$	0.2 – 0.5	0.40 ± 0.05	0.19 ± 0.02	0.20 ± 0.02
$g', u' - i'$	1.0 – 1.5	0.42 ± 0.06	0.19 ± 0.02	0.21 ± 0.03

By analyzing only a part of the avaible data, we can confirm the occurrence of the extra-tidal stars in M92. In addition, although M92 is considered one of the most typical Galactic globular cluster, we found that the ratio between MS stars (located across the turn-off region) and HB stars shows a well defined radial gradient. However, before we can draw firm conclusions concerning the occurrence of this last phenomenon a complete sample of cluster stars is required.

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