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Star count ratios in the Galactic globular cluster M92

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Abstract. We present both space (ACS@HST: F814W, F606W, F475W) and ground-based (MEGACAM@CFHT: u*, g',i',r',z') photometry of the Galactic Globular Cluster (GGC) M92. Space data are located close to the cluster center, while the ground-based data cover one square degree around the cluster center. We investigate the ratios between Horizontal Branch (HB), Main Sequence (MS) and Red Giant Branch (RGB) stars across the body of the cluster. We found that the star counts agree quite well with the predicted evolutionary lifetimes.

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

1. Introduction

Globular clusters typically host simple stellar populations, therefore they are the most suitable laboratories for testing stellar evolution theory. We selected M92 ([Fe/H]=−2.28 dex, Harris 1996) since it is one of the most popular templates for old very metal-poor GGCs. Its intrinsic parameters are well-known. M92 is located far from the Galactic plane (l=68.34° b=34.86°, Harris 1996) and it has low reddening ($E(B-V) = 0.02$, Harris 1996) and a minimal contamination by field stars. In this work, we focused our attention on the relative ratios between the star counts in different evolutionary phases. The number of stars in a specific evolutionary phase is proportional to the time spent in that phase and in turn to the internal burning rates. The strategy that we adopted to count stars and to study the spatial distribution of their ratios is described in Castellani et al. (2007).

2. Data and reduction strategy

The ground-based dataset includes deep and shallow images collected in the Sloan Digital Sky Survey (SDSS) bands (u', g', r', i', z') with

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Table 1. Star count ratios between HB, MS and RGB stars located at increasing radial distances. In the last line we list the theoretical predictions for the same values.

Distance	*HB/MS*	*HB/RGB*	*RGB/MS*
$r < 0.5'$	0.13 ± 0.02	0.22 ± 0.02	0.62 ± 0.04
$0.5' < r < 1.2'$	0.11 ± 0.01	0.20 ± 0.02	0.54 ± 0.03
$1.2' < r < 3.6'$	0.11 ± 0.01	0.22 ± 0.03	0.49 ± 0.03
$r > 3.6'$	0.12 ± 0.01	0.21 ± 0.03	0.57 ± 0.04
Theory	0.10 ± 0.06	0.18 ± 0.01	0.57 ± 0.02

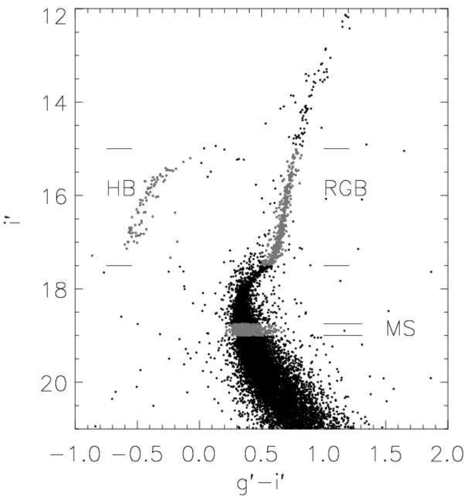

Fig. 1. Colour-magnitude diagram for the third region. The selected stars are in grey colour.

the MegaCam@CFHT, for a total of 57 dithered exposures. MegaCam is the largest astronomical CCD mosaic built to date, based on 36 (2048×4612 pixel) CCDs covering a 1°×1° field-of-view and with a spatial sampling of 0.187”/px (Boulade et al. 2003).

Initial PSF photometry was performed running the DAOPHOTII/ALLSTAR/ALLFRAME programs (Stetson 1987, 1994) for each chip. The final photometry was performed running ALLFRAME simultaneously over the entire dataset and rescaling each individual catalog to a common reference system using DAOMASTER. To overcome the crowding in the central regions, we supplemented the ground-based data with two ACS@HST pointings collected in the F814W, F606W and F475W filters. The calibration curves were estimated using secondary standards provided by Clem et al. (2007).

3. Results and discussion

To investigate the radial distribution of the stars in different evolutionary phases we estimated the ratios between HB stars, MS stars and RGB stars as a function of radius. To sample the same luminosity we reconstructed the normalized cumulative flux in i' band and we divided the cluster in four concentric regions with 25% of the normalized integrated flux. We counted the MS stars within 0.25 mag of the Turn Off (TO) point ($M_{i'} = 18.8$ mag) while the RGB stars were counted for i' between 15 mag and 17.5 mag (see Fig. 1). The HB/MS, HB/RGB and RGB/MS population ratios are listed in Table1.

In order to compare our empirical results with theoretical predictions we assumed a distance modulus DM_0=14.64 (Harris 1996) and a reddening $E(B-V) = 0.02$ for the theoretical models provided by Pisa Library. The predicted evolutionary lifetimes for the MS and RGB stars were obtained using the track of a $0.7M_\odot$ star as estimated from the TO point of the 13 Gyr ([Fe/H]=−2.32, $Y = 0.25$) isochrone. The HB lifetime is the mean value of the HB lifetimes estimated for two stellar structures with M=$0.64M_\odot$ and M=$0.75M_\odot$ (see Table 1). We can confirm that the HB/MS, HB/RGB and RGB/MS star count ratios are in good agreement with the theoretical evolutionary time ratios.

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