



Wide-field study of a heavily populated globular cluster system: the case of NGC 1172

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Resumen / Se presentan los resultados preliminares del estudio fotométrico de campo amplio del sistema de cúmulos globulares (SCG) de la galaxia elíptica de campo NGC 1172, realizado a partir de imágenes obtenidas con GMOS en Gemini Sur en los filtros g' , r' e i' . El objetivo del trabajo es caracterizar el SCG de la galaxia para revelar indicios sobre su formación y evolución.

Abstract / Preliminary results of the photometric wide-field study of the globular cluster system (GCS) of the field elliptical galaxy NGC 1172 are presented. The images used were obtained with GMOS in Gemini South in the filters g' , r' and i' . The aim of this work is to characterize the GCS of the host galaxy in order to find clues about its formation and evolution.

Keywords / galaxies: star clusters: general — galaxies: elliptical and lenticular, cD — galaxies: evolution

1. Introduction

Elliptical galaxies are thought to have accreted most of their material through minor mergers since $z \sim 2$ (van Dokkum et al., 2010). This implies that elliptical galaxies in dense environments have undergone different growth mechanisms than the few ones found in low-density habitats (Richtler et al., 2015). Because of this, elliptical galaxies in groups are an interesting subject of study, since they provide a suitable scenario for examining evolutionary processes in action (Bassino & Caso, 2017). Massive early-type galaxies (ETGs) usually present rich globular cluster systems (GCS), where clues about their evolutionary history can be found since they are good tracers of the star formation history (e.g. Pota et al., 2015; Caso et al., 2019) and also, of the gravitational interactions that a galaxy might experience (e.g. Escudero et al., 2015). Accretion processes or mergers may leave traces in the shape of disruptions in the GCS' spatial distribution, or even in the presence of younger populations when the interaction causes a star formation event (e.g. Caso et al., 2015; Bassino & Caso, 2017).

One of the most studied characteristics of GCSs both in the Milky Way and in other galaxies, is the bimodality usually found in their colour distribution. Though this separation could be an effect of an age gap, spectroscopic studies have shown the biggest difference between these two subpopulations lies in their metal content (Brodie et al., 2012). Despite globular clusters (GCs) being all metal poor, the “blue” subpopulation shows a significantly lower value of metallicity than the “red” one. Recent studies have found in some ETGs a third subpopulation of GCs with intermediate colours (Sesto

et al., 2018). These clusters are probably young, possibly created due to a merger that involved enough gas to trigger star formation.

NGC 1172 is an elliptical galaxy that presents no bright companions within a $30'$ radius, though it has been suggested it could be a member of the NGC 1209 group (Sandage, 1978). Previous photometric studies of its GCS performed with ACS/WFC images (Cho et al., 2012) found a rich population of clusters, with a specific frequency of $S_N \sim 9$, which is significantly high for a galaxy of this magnitude (Harris et al., 2013). In this work, we perform a wide field photometric study of the GCS in order to cover its full extension, and look for evidences of interactions in its properties.

2. Observations and Photometry

2.1. Processing

Figure 1 shows the observed fields. The CCD images for the central field and the two adjacent ones were obtained in programmes GS-2016B-Q-37 (PI: Caso) and GS-2017B-Q-38 (PI: Caso), respectively. All fields were observed in the g' , r' and i' filters with a 2×2 binning, resulting in a scale of $0.146 \text{ arcsec pixel}^{-1}$. From the Gemini Observatory Archive (GOA*), calibration images were obtained in order to carry out bias and flat-field corrections using Gemini routines within IRAF. The images of each filter are slightly dithered so that the combination of them removes bad pixels and cosmic rays, as well as the gaps between CCDs.

*<http://archive.gemini.edu/>

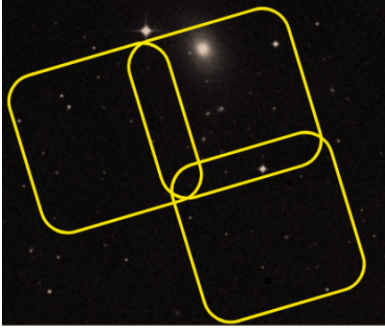


Figure 1: SDSS image with the observed fields, both central and adjacent, marked with yellow lines.

2.2. Source Selection

We used SExtractor (Bertin & Arnouts, 1996) to identify sources in the three fields, combining the selection obtained using the *gaussian* and *mxhat* filters to ensure the highest possible level of completeness. The selection criteria to obtain a catalog of point-like sources was $\text{CLASS STAR} > 0.5$. The final photometry was performed using a PSF fitting for which we used the task ALLSTAR, which gives for each object a goodness fit. These were used to refine the selection.

2.3. Photometric Calibration

The photometry was transformed to the standard system following the guidelines described in the Gemini observatory website^{**}. We used observations of the E2-A standard star field (Smith et al., 2002) taken in the same programmes. In addition to this, a correction for galactic extinction was also applied, using the absorption coefficients provided by Schlafly & Finkbeiner (2011).

2.4. GC selection

Once the calibrated and corrected magnitudes for all point-sources were obtained, a selection was made using the colour criteria that is typical of GC populations (Faifer et al., 2011). In Fig. 2 the dashed lines show the chosen limits, $0.4 < (g' - i')_0 < 1.4$, $0.4 < (g' - r')_0 < 1$ and $-0.1 < (r' - i')_0 < 0.5$. In Fig. 3, we present the colour-magnitude diagram with no magnitude limits established yet, since the completeness test is currently being carried out. With this selection, we obtain a total of ~ 1300 GCs. For a more accurate estimation and considering the usual depth reached in GMOS images for this filter, we considered a limit in magnitude of $i'_0 = 25$, which leaves us with ~ 500 candidates.

3. Results

3.1. Colour distribution

Fig. 4 shows the colour distribution for all the candidate GCs with $i'_0 < 25$. As mentioned before, in GCSs this distribution is expected to show a clear bimodality.

^{**}<https://www.gemini.edu/>

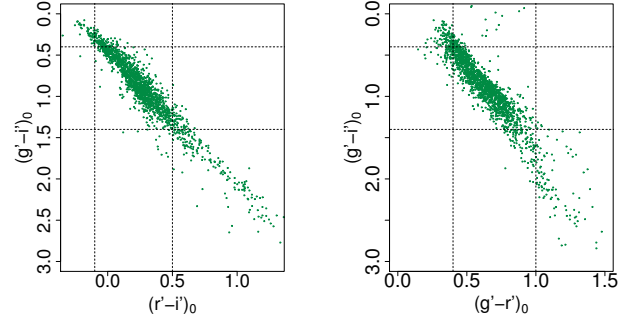


Figure 2: Colour-colour diagrams for all SExtractor point-like sources. Dashed lines show the limits used for the selection.

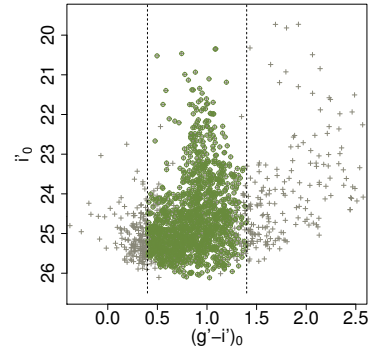


Figure 3: Colour magnitude diagram where grey crosses represent all SExtractor point-like sources, and green circles represent those that fulfill the colour criteria.

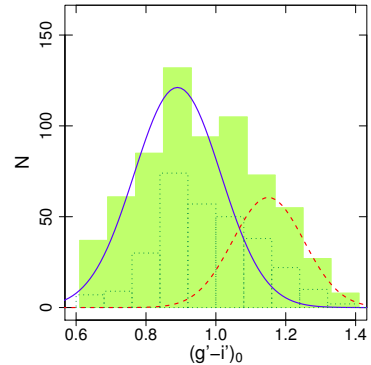


Figure 4: Colour distribution for candidate GCs with $i'_0 < 25$ (green histogram). The superimposed empty histogram shows the distribution for the central field only. Blue and red lines show Gaussian fits with the typical mean colours for the “blue” and “red” subpopulations.

Though in this case two peaks at the usual colours are found, $(g'_0 - i'_0) \sim 0.85$ and $(g'_0 - i'_0) \sim 1.15$, there is also a significant over density at around $(g'_0 - i'_0) \sim 1.05$. Even if we subtract the GCs present in the adjacent fields, it can be seen that the central one also shows this apparent third subpopulation which does not fall into neither the “red” nor the “blue” ones. Though further analysis is required to confirm this, the fact that we find GCs that do not belong to neither of the classic subpopulations, could mean that we are in the presence of a younger

subpopulation, possibly born from a starburst event as a consequence of a merger or accretion process.

3.2. Radial distribution

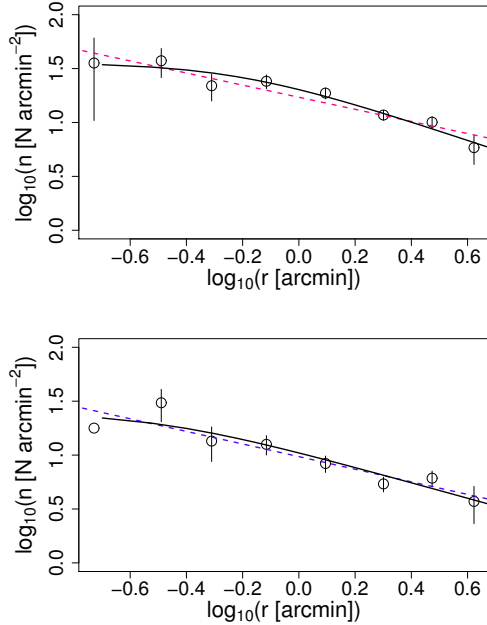


Figure 5: Radial distribution for candidate GCs with $i'_0 < 25$ in the central field (top panel) and for the blue subpopulation in the central field (lower panel). The open circles represent the corresponding histogram points. In both cases, dotted lines represent a power law fit, and solid lines, a Hubble-Reynolds law fit.

In Fig. 5 we show the radial distribution for those GCs situated in the central field, and for the blue subpopulation in particular. In order to consider the effect that can be seen in the regions closer to the galactic centre, where both the saturation in the image and the physical effect of stronger tidal forces cause a decrease in the amount of GCs, a Hubble-Reynolds law was fitted (Dirsch et al., 2003). The results point to an apparent agreement between the complete sample and the blue subpopulation (GCs with $(g' - i')_0 < 0.95$), though further analysis is currently being performed over this field and the adjacent ones.

3.3. Effective radii distribution

In Fig. 6 we show the effective radii distribution for candidate GCs, as obtained from the analysis performed on the ACS/WFC images. The values for the radii were obtained with ISHAPE (Larsen, 1999). The peak of the distribution is $0.026''$, which corresponds to ~ 3 pc for a distance of 21 Mpc (Tonry et al., 2001). This value is in agreement with results for the Virgo cluster from

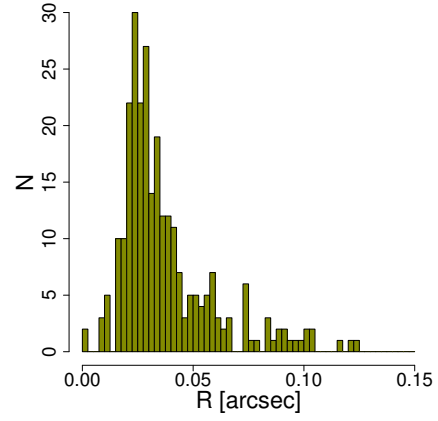


Figure 6: Effective radii distribution for candidate GCs from our ACS/WFC photometry.

Jordán et al. (2005).

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