Star Clusters: From the Milky Way to the Early Universe
Proceedings IAU Symposium No. 351, 2019
A. Bragaglia, M. Davies, A. Sills & E. Vesperini, eds.

doi:10.1017/S1743921319006574

Wide-field study of NGC 1172 and its rich globular cluster system

Ana I. Ennis[1,2], **Lilia P. Bassino**[1,2], **Juan P. Caso**[1,2], **Matías Gómez**[3] and **Bruno J. De Bórtoli**[1,2]

[1]Facultad de Ciencias Astronómicas y Geofísicas de la Universidad Nacional de La Plata, and Instituto de Astrofísica de La Plata (CCT La Plata – CONICET, UNLP), Paseo del Bosque S/N, B1900FWA La Plata, Argentina

[2]Consejo Nacional de Investigaciones Científicas y Técnicas, Godoy Cruz 22990, C1425FQB, Ciudad Autónoma de Buenos Aires, Argentina

[3]Departamento de Ciencias Físicas, Universidad Andrés Bello, Chile, República 220, Santiago, Chile

Abstract. We present preliminary results of the wide-field photometric study of the isolated elliptical galaxy NGC 1172, and its globular cluster system. Our data was obtained with the GMOS camera mounted on the Gemini South telescope, in the g', r', i' and z' bands. The aim of this work is to further our understanding of the evolution of NGC 1172, and to look for possible explanations for its unusual high specific frequency.

Keywords. galaxies: elliptical and lenticular, cD; galaxies: evolution; galaxies: star clusters: individual: NGC1172

1. Introduction

The evolutionary history of early-type galaxies has been a popular subject of study for decades, yet there are still many unanswered questions regarding the path that led to their current observed properties. Most elliptical galaxies are found in high density environments such as clusters, where they are thought to have undergone accretion processes and multiple mergers. Those inhabiting low density environments such as groups or in particular the ones located in the field seem to undergo slightly different processes. The lack of neighbours means the interactions that galaxies in these habitats experience are few, and usually involve less gas (i.e. dry mergers).

Due to their age being usually comparable with that of the galaxy that hosts them, globular clusters (GCs) are useful for learning about the earlier stages of its evolution. However, isolated galaxies usually have globular cluster systems (GCSs) consisting of very few GCs, which makes it difficult to obtain statistically significant properties of the population based on integrated light analysis. Because of this, isolated elliptical galaxies which present highly populated GCSs are of great interest and can provide us with much needed insight on the formation and evolution of massive galaxies in such environments.

NGC 1172 is an isolated elliptical galaxy with no bright neighbours in a radius of at least 30' around it. It presents an intermediate intrinsic luminosity of $M_V \sim -20.6$ (de Vaucouleurs *et al.* 1991), adopting a value of $\sim$21.20 Mpc for the distance (Tully *et al.* 2013, SBF method), and a specific frequency of 7.14 (Cho *et al.* 2012) which is particularly high for its brightness, especially considering the environment. It does not present signs of recent interactions at first glance, as no trails or peculiar features can be spotted on its surface brightness distribution.

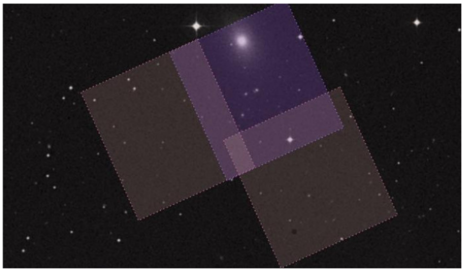

Figure 1. The fields indicated with pink squares over a DSS image. The darker square is the central one, which includes the galaxy.

In this work, we present preliminary results for the wide-field study of the GCS of NGC 1172, including its colour distribution, its radial distribution and its luminosity function.

2. Observations and processing

Three fields were observed in 2016 and 2017 for this work, a central one including the galaxy and two adjacent ones. The observations were obtained with the Gemini Multi-Object Spectrograph (GMOS) mounted on the Gemini South telescope in Cerro Pachón, Chile (Programs GS-2016B-Q-37 and GS-2017B-Q-38), in the g', r', i' and z' filters, the latter only for the central field. The processing of the images was carried out using IRAF and tasks within it, using bias and flat-fields images obtained from the GOA, as well as z' blank sky images which were necessary to correct the night-sky fringing present in this filter.

The adjacent fields were used to study the GCS in its full extension and to obtain an estimate of the contamination in order to make the necessary corrections. The distribution of the fields can be seen in Figure 1.

The field of standards E2-A (Smith *et al.* 2002) was also observed in the same programs, acquiring images of both long and short exposure in order to obtain the best quality photometry for faint and bright stars, respectively. The processing for these images was done in the same way as the science images, resulting in photometry of standard stars which provided us with the necessary coefficients to calibrate our photometry.

Using the software SExtractor (Bertin & Arnouts 1996), we built a catalogue of point-like sources present across the three fields. A Gaussian filter and a mexhat one were combined in this process as to detect as many sources as possible, and the initial selection was made using the "stellarity index", choosing those for which it was larger than 0.5. This index ranges from 0 to 1, with 0 being the value that corresponds to extended objects such as background galaxies. The PSF photometry was performed using DaoPhot tasks, which also run statistic tests on the goodness of the fits, thus allowing us to perform a second selection.

3. Results

In order to select from our point-like sources catalogue those that can be considered GC candidates, we examined the colour-magnitude diagram shown in the left panel of Figure 2. Out of all the detected sources, we consider as candidates those that fall within the colour limits applied on the three possible colour-colour combination according to the typical values found in the literature (Faifer *et al.* 2011; Bassino & Caso 2017). In addition to this, we considered limits in magnitude as well, the one on the brighter side being a tentative separation from UCD candidates (Mieske *et al.* 2006), while the one one the fainter side corresponds to a completeness of ∼80%.

https://doi.org/10.1017/S1743921319006574 Published online by Cambridge University Press

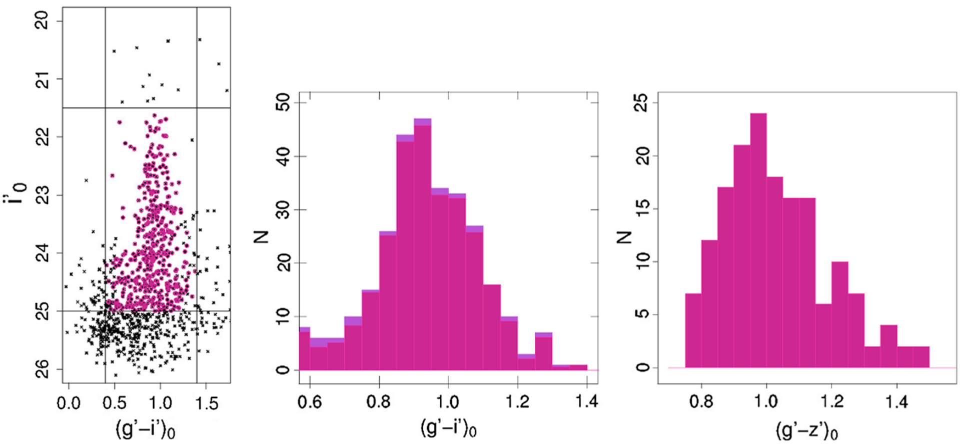

Figure 2. Left panel: Colour-magnitude diagram for all the point-like sources in black crosses, with those that fulfill the colour and magnitude criteria marked with pink circles. Middle panel: Colour distribution for the GC candidates in all fields for $(g' - i')_0$, in a darker purple before being corrected for contamination, lighter after correction. Right panel: Colour distribution for the GC candidates for $(g' - z')_0$ in the central field.

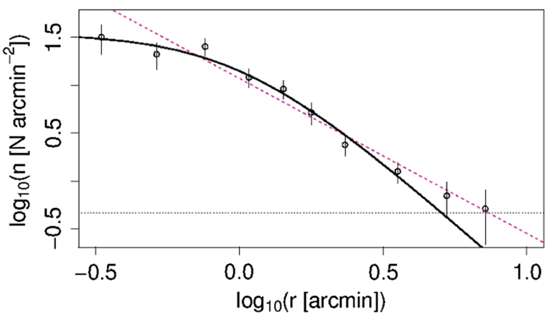

Figure 3. Radial distribution of all GC candidates (circles) with its corresponding errors. The dotted pink line shows a linear fit, while the black solid one shows the Hubble-Reynolds law fit. The dotted horizontal black line shows the background level.

In the middle and left panels of Figure 2 we present the colour distribution for the GC candidates. In the left panel, the $(g' - i')_0$ colour distribution for the GCs from the three fields shows a clear dominance of the blue subpopulation (around $(g' - i')_0 \sim 0.9$). In the right panel, the $(g' - z')_0$ subpopulation corresponding only to the GCs in the central field allows us to see that again, the blue subpopulation (around $(g' - z')_0 \sim 0.96$) is larger than the red in a proportion not usually seen in this galaxy type. Due to the also peculiar narrowness of the distributions, it was impossible to acquire statistically accurate fits of a bimodal distribution, though the asymmetries around the most evident peaks hint at the presence of two subpopulations of GCs with different metallicities.

Once our GC candidates were selected, we analysed the radial distribution, as shown in Figure 3. It presents an obvious flattening towards the center of the galaxy due to the increase in the tidal destruction of GCs in that region (Kruijssen *et al.* 2011), combined with an observational bias, and the expected decay towards the outer regions. A Hubble-Reynolds law (Binney & Tremaine 1987; Dirsch *et al.* 2003) was fitted since it takes into account these effects.

https://doi.org/10.1017/S1743921319006574 Published online by Cambridge University Press

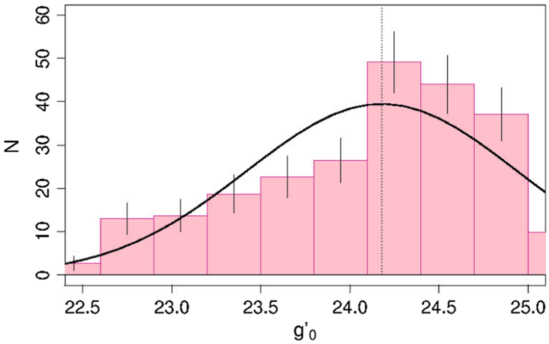

Figure 4. Luminosity function for the GC candidates, with a gaussian fit shown in a solid curve. The solid lines at the top of each bin represent the corresponding error.

The luminosity function shown in Figure 4 has a Gaussian fit in solid lines, using the turn-over magnitude marked with a dotted line as obtained by Cho *et al.* (2012) with ACS photometry, which is deeper than our own and thus more reliable for this parameter.

Further work is being carried out with the addition of NIR observations that are being reduced currently and that will allow us to have a much deeper insight into the GCS.

Acknowledgments

This work was funded with grants from Consejo Nacional de Investigaciones Científicas y Técnicas de la República Argentina (PIP 112-201101-00393), Agencia Nacional de Promoción Científica y Tecnológica (PICT-2013-0317), and Universidad Nacional de La Plata (UNLP 11-G124), Argentina. Based on observations obtained at the Gemini Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the NSF on behalf of the Gemini partnership: the National Science Foundation (United States), the National Research Council (Canada), CONICYT (Chile), Ministerio de Ciencia, Tecnología e Innovación Productiva (Argentina), and Ministério da Ciência, Tecnologia e Inovação (Brazil). The Gemini programme ID is GS-2016B-Q-37 and GS-2017B-Q-38. This research has made use of the NED, which is operated by the Jet Propulsion Laboratory, Caltech, under contract with the National Aeronautics and Space Administration.

References

Bassino, L. P. & Caso, J. P. 2017, *Monthly Notices of the Royal Astronomical Society*, 466, 4259

Bertin, E. & Arnouts, S. 1996, *Astronomy & Astrophysics, Supplement*, 117, 393

Binney, J. & Tremaine, S. 1987, Princeton

Cho, J., Sharples, R. M., Blakeslee, J. P., *et al.* 2012, *Monthly Notices of the Royal Astronomical Society*, 422, 3591

de Vaucouleurs, G., de Vaucouleurs, A., Corwin, H. G., *et al.* 1991, Third Reference Catalogue of Bright Galaxies.

Dirsch, B., Richtler, T., & Bassino, L. P. 2003, *Astronomy & Astrophysics*, 408, 929

Faifer, F. R., Forte, J. C., Norris, M. A., *et al.* 2011, *Monthly Notices of the Royal Astronomical Society*, 416, 155

Kruijssen, J. M. D., Pelupessy, F. I., Lamers, H. J. G. L. M., *et al.* 2011, *Monthly Notices of the Royal Astronomical Society*, 414, 1339

Mieske, S., Hilker, M., Infante, L., *et al.* 2006, *Astrophysical Journal*, 131, 2442

Smith, J. A., Tucker, D. L., Kent, S., *et al.* 2002, *Astrophysical Journal*, 123, 2121

Tully, R. B., Courtois, H. M., Dolphin, A. E., *et al.* 2013, *Astrophysical Journal*, 146, 86

https://doi.org/10.1017/S1743921319006574 Published online by Cambridge University Press