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Nearly coeval intermediate-age Milky Way star clusters at very different dynamics evolutionary stages

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ABSTRACT

We report astrophysical properties of 12 Milky Way open clusters located beyond a 2 kpc circle around the Sun by using deep optical photometry. We estimated their age and metallicities on the basis of a maximum likelihood approach using astrometric members determined from *Gaia* DR2 data. The studied clusters turned out to be of intermediate-age (0.8–4.0 Gyr), with metallicities spanning the range [Fe/H] ~ -0.5–$+0.1$ dex, and distributed within the general observed trend of the Milky Way disc radial and perpendicular metallicity gradients. As far as we are aware, these are the first metal abundance estimates derived for these clusters so far. From the constructed stellar density radial profiles and cluster mass functions we obtained a variety of structural and internal dynamics evolution parameters. They show that while the innermost cluster regions would seem to be mainly shaped according to the respective internal dynamics evolutionary stages, the outermost ones would seem to be slightly more sensitive to the Milky Way tidal field. The nearly coeval studied clusters are experiencing different levels of two-body relaxation following star evaporation; those at more advanced stages being more compact objects. Likewise, we found that the more important the Milky way tides, the larger the Jacobi volume occupied by the clusters, irrespective of their actual sizes and internal dynamics evolutionary stages.

Key words: techniques: photometric – open clusters and associations: general.

1 INTRODUCTION

The study of Galactic open clusters has long helped improve our understanding of the Milky Way disc formation and evolution. For instance, from their positions, ages and metallicities, the radial metallicity gradient as well as that perpendicular to the Galactic plane have been derived, which in turn have been used to constrain Milky Way formation theoretical models (Magrini et al. 2009; Sahijpal & Kaur 2018). Different photometric and spectroscopic surveys have been exploited in order to derive improved cluster parameters and first estimates of the astrophysical properties of unstudied ones (e.g. Cantat-Gaudin et al. 2018; Carrera et al. 2019). Although there has been an interesting progress in constructing open clusters' parameter catalogues (Dias et al. 2002; Kharchenko et al. 2013), the remaining work is still huge, because of the growing number of identified new open clusters (Cantat-Gaudin et al. 2018; Castro-Ginard et al. 2018; Ferreira et al. 2019).

With the aim of contributing to a comprehensive knowledge of the open cluster system, we searched the National Optical Astronomy Observatory (NOAO) Science Data Management Archives[1] looking for Washington photometric system images centred on mostly unstudied open cluster fields. We chose the Washington photometric system because of our experience in estimating star cluster fundamental parameters and its ability in estimating cluster metallicities (see e.g. Piatti, Clariá & Ahumada 2004; Piatti, Dias & Sampedro 2017, and references therein). From the search, we found that the Cerro Tololo Interamerican Observatory (CTIO) programme no. 2008A-0001 (PI: Clariá) was aimed at observing nearly 80 mostly unstudied open clusters. We have started to analyse them in Angelo et al. (2018) and Angelo et al. (2019a). Here, we focus on all the remaining clusters with ages $\sim$1 Gyr, because their structural properties tell us about the wide range of internal dynamical evolutionary stages they can span.

In Section 2 we present the unpublished publicly available Washington data sets used in this work, alongside a brief description

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[1]http://www.noao.edu/sdm/archives.php.