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Characterizing dynamical stages of open clusters located in the Sagittarius spiral arm

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ABSTRACT

The study of dynamical properties of Galactic open clusters (OCs) is a fundamental prerequisite for the comprehension of their dissolution processes. In this work, we characterized 12 OCs, namely: Collinder 258, NGC 6756, Czernik 37, NGC 5381, Ruprecht 111, Ruprecht 102, NGC 6249, Basel 5, Ruprecht 97, Trumpler 25, ESO 129−SC32, and BH 150, projected against dense stellar fields. In order to do that, we employed Washington CT_1 photometry and *Gaia* DR2 astrometry, combined with a decontamination algorithm applied to the three-dimensional astrometric space of proper motions and parallaxes. From the derived membership likelihoods, we built decontaminated colour–magnitude diagrams, while structural parameters were obtained from King profiles fitting. Our analysis revealed that they are relatively young OCs (log(t yr^{-1}) ∼7.3–8.6), placed along the Sagittarius spiral arm, and at different internal dynamical stages. We found that the half-light radius to Jacobi radius ratio, the concentration parameter and the age to relaxation time ratio describe satisfactorily their different stages of dynamical evolution. Those relative more dynamically evolved OCs have apparently experienced more important low-mass star loss.

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

1 INTRODUCTION

It is known that the majority of stars are born embedded within giant molecular clouds (Lada & Lada 2003) and form stellar aggregates named associations or open clusters (OCs). Whilst the first are loose and gravitationally unbound groups (typical dissolution times between ∼10 and 100 Myr; Moraux 2016), the latter are long-lived stellar structures and their diversity in terms of age, stellar content, and metallicity makes them ideal tracers of the Galaxy structure, providing information regarding its kinematical evolution and chemical enrichment.

The initial evolutionary stages of the OCs have critical impact on their subsequent dynamical evolution, since the early gas-expulsion process (caused by, e.g. supernova and stellar winds during the first ∼3 Myr; Portegies Zwart, McMillan & Gieles 2010) cause less than 10 per cent of embedded OCs to survive emergence from molecular clouds (Lada & Lada 2003). Those that are massive enough to survive this initial phase enter subsequent phases, when dynamical time-scales become continuously smaller than mass-loss time-scales due to stellar evolution. The investigation of these structures helps to constrain the initial conditions assumed by, e.g. *N*-body simulations aimed at reproducing observable quantities of OCs at later evolutionary stages.

During the long-term evolution, the interplay between several destructive effects (e.g. tidal stripping, collisions with molecular clouds, evaporation of stars due to internal relaxation) causes the OC's stellar content to be gradually depleted until its dissolution amongst the general Galactic field. How stellar OCs dissolve is a debated topic (Bica et al. 2001; Pavani & Bica 2007; Piatti, Dias & Sampedro 2017) and uniform characterizations of evolved OCs, possibly covering different parameters and positions within the Galaxy, are important to constrain evolutionary models and thus to clarify this subject.

In this context, the second release of the *Gaia* catalogue (Gaia Collaboration 2018) inaugurated a new era in astronomy. The availability of astrometric information with high precision (typically $\lesssim$0.1 mas and $\lesssim$0.1 mas yr^{-1} for parallaxes and proper motion components, respectively) allowed the discovery of new OCs (Borissova et al. 2018; Cantat-Gaudin et al. 2018; Ferreira et al. 2019) and a more precise characterization of already catalogued ones (e.g. Dias et al. 2018; Kos et al. 2018)

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