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Three new Galactic star clusters discovered in the field of the open cluster NGC 5999 with *Gaia DR2*

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ABSTRACT

We report the serendipitous discovery of three new open clusters, named UFMG 1, UFMG 2, and UFMG 3 in the field of the intermediate-age cluster NGC 5999, by using *Gaia DR2* data. A colour-magnitude filter tailored for a proper selection of main-sequence stars and red clump giants turned evident the presence of NGC 5999 and these three new stellar groups in proper motion space. Their structural parameters were derived from King-profile fittings over their projected stellar distributions and isochrone fits were performed on the clusters cleaned colour-magnitude diagrams built with *Gaia* bands to derive their astrophysical parameters. The clusters projected sky motions were calculated for each target using our members' selection. Distances to the clusters were inferred from stellar parallaxes through a Bayesian model, showing that they are marginally consistent with their isochronal distances, considering the random and systematic uncertainties involved. The new clusters are located in the nearby Sagittarius arm ($d \sim 1.5$ kpc) with NGC 5999 at the background ($d \sim 1.8$ kpc). They contain at least a few hundred stars of nearly solar metallicity and have ages between 100 and 1400 Myr.

Key words: open clusters and associations: general – Galaxy: stellar content.

1 INTRODUCTION

The spatial density fluctuations of low-Galactic latitude stellar populations make difficult the identification and characterization of open clusters for studies of the history and structure of the Galactic disc. The recent *Gaia DR2* (Gaia Collaboration 2016, 2018a; Evans et al. 2018) provides precise astrometric and photometric data for an unprecedented number of stars, allowing us to better investigate and/or find many of these objects, normally suppressed by both high-density stellar fields and extinction.

Nowadays there are more than 2500 known open clusters (Dias et al. 2002; Kharchenko et al. 2013). With the advent of near-infrared surveys such as 2MASS (Skrutskie et al. 2006) and VVV (Minniti et al. 2010), new objects have been discovered, notably young clusters embedded in molecular clouds that were invisible in the optical due to high absorption (e.g. Bica et al. 2003; Borissova et al. 2014; Barbá et al. 2015). In the optical, the Gaia mission has acquired whole sky high-precision proper motions and parallaxes which are suited to an accurate distinction between cluster and field stars due to the expected confined loci of cluster stars in the astrometric space. This has led to an increase in the number of open clusters discovered recently (Cantat-Gaudin et al. 2018; Castro-Ginard et al. 2018; Ryu & Lee 2018; Torrealba, Belokurov & Koposov 2018).

We have been carrying out a study of open clusters in dense stellar fields using VVV, 2MASS, and more recently Gaia to fully characterize such objects. One of these objects is NGC 5999, located in the direction of the Galactic disc, with Galactic coordinates $\ell = 326^\circ$ and $b = -1.93^\circ$ (Dias et al. 2002). NGC 5999 is approximately 400 Myr old, with distance determinations ranging from 1.6 to 2.5 kpc and reddening $E(B-V) = 0.45 \pm 0.05$ (Santos & Bica 1993; Piatti, Claria & Bica 1999; Dias et al. 2002; Netopil et al. 2007; Kharchenko et al. 2013; Moni Bidin et al. 2014). The Milky Way Star Clusters project (MWSC; Kharchenko et al. 2013), which is based on 2MASS photometry and PPMXL (Roeser, Demleitner & Schilbach 2010) astrometry, gives for NGC 5999: $\log(t(\mathrm{yr})) = 8.600 \pm 0.095$ (with two stars used to calculate the age), $d = 1629$ pc, $E(B-V) = 0.437$, core radius $r_c = 0.71 \pm 0.09$ pc, and tidal radius $r_t = 6.05 \pm 0.83$ pc. Piatti et al. (1999) employed *BVI* observations aided by integrated spectroscopy from Santos & Bica (1993) to derive for NGC 5999 the following parameters: $t = 400 \pm 100$ Myr, $d = 2.2 \pm 0.4$ kpc, and $E(B-V) = 0.45 \pm 0.05$. Moni Bidin et al. (2014) investigated a possible connection between NGC 5999 and the planetary nebulae VBe 3, located at 5 arcmin from the cluster centre. To do this, they observed spectroscopically four members of the cluster and the planetary nebulae, coming to the conclusion

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