Searching for open clusters in Gaia DR3 using a parallax-blind approach

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Gaia data is providing a unique opportunity to explore the structure of the Milky Way by discovering more and more of one of its best tracers: open clusters. Innovative algorithms, supported by Gaia accurate proper motions, parallaxes, photometry, and radial velocities (whenever available), have identified hundreds of new clusters of stars across the Galactic disk and bulge in only a few years. However, parallax measurements as a key ingredient in those techniques might lead to the possible loss of clusters when individual-associated uncertainties are relatively high. In this work, we will describe our attempts to performance a parallax-blind search of open clusters and show that there is still room for further discoveries thanks to the precious information contained in such an unprecedented database.

1 - Context

The searching for new open clusters (OCs) in the Milky Way and their full characterization is crucial to trace the spiral structure of the Galaxy and understand the evolution of different sections of its components over time. The classic definition of an OC is a group of stars sharing position, proper motion, and chemical composition, since they were formed in a single event. In the last years, the European space mission Gaia is providing precise positions, kinematics and stellar parameters for more than one billion stars aiming to understand the origin and evolution of our own Galaxy (Gaia Collaboration 2016). Since the first data release, a pleiad of hundreds of candidate clusters have been unveiled in that database using different clustering techniques (e.g. Cantat-Gaudin et al. 2018a, 2019, 2022; Castro-Ginard et al. 2019, 2020, 2022; He et al. 2020), thus dramatically increasing the list of OCs in our Galaxy.

2 - Methodology

We followed a technique originally designed for the detection of dwarf satellites in SDSS/DES data (e.g. Koposov et al. 2015; Bechtol et al. 2015). As a brief description, for each of the 2º x 2º fields in which we have divided the 0º < *l* < 360º and -30º < *b* < 30º section of the Galaxy as observed by Gaia, we sliced the proper motion space in bins of $\delta\mu = 1\, mas\, yr^{-1}$ and obtained density maps of all the *G* <= 18 sources.

Those maps are convolved with two gaussian filters with kernels widths 5' and 15' and we focused on those spatial pixels with relative significance (see definition in Koposov et al. 2007) above 3σ. The overdensities composed of at least 10 stars are initially considered as an OC and move forward in the analysis.

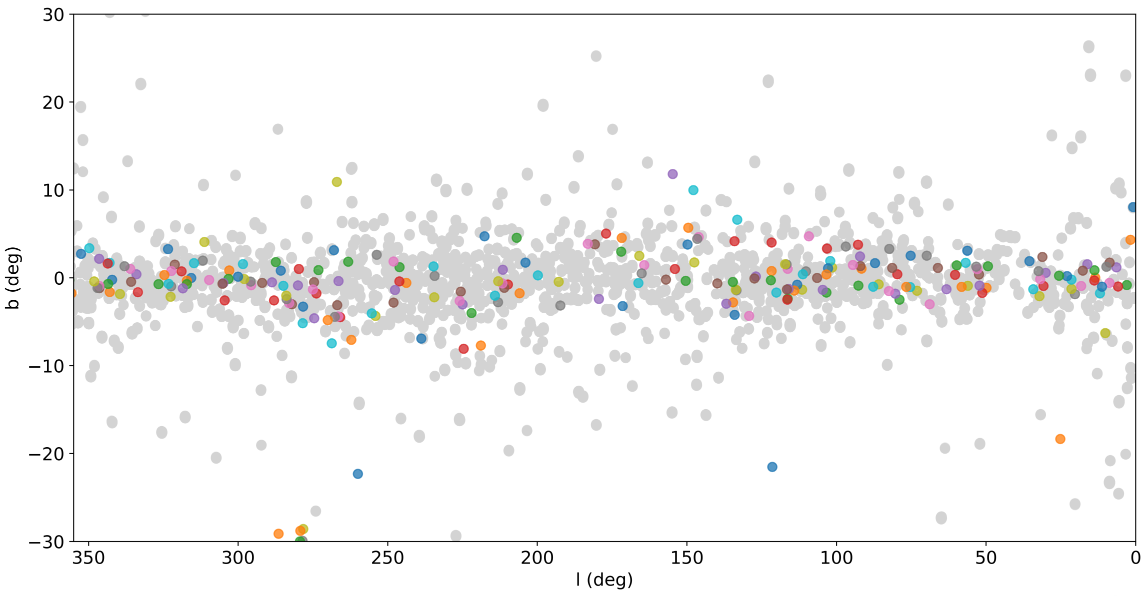

Fig. 1: Distribution of detected overdensities with S >= 5σ, where color and grey points represent candidate and known objects(color) and known (grey), respectively.

3 - Preliminary results

We found 244 new stellar overdensities and recovered 2860 objects previously reported in OC/GC catalogs (see Fig. 1). As for the known clusters, we recover a 72% of the entire population with a significant deficit in nearby clusters, which may be related to their low projected-density and/or our quality cuts in significance, number of stars and total proper motion dispersion.

These candidate clusters appear as compact co-moving groups of stars, which are located at all heliocentric distances (only considering those parallaxes with relative errors < 20%). The color-magnitude diagrams (see Fig. 2) are consistent with the presence of a well-differentiated stellar system along that line-of-sight.

We conclude that new techniques will allow us to unveil more clusters based on the same Gaia data, thus confirming that the information collected by this mission is still full of surprises in the study of our own neighborhood.

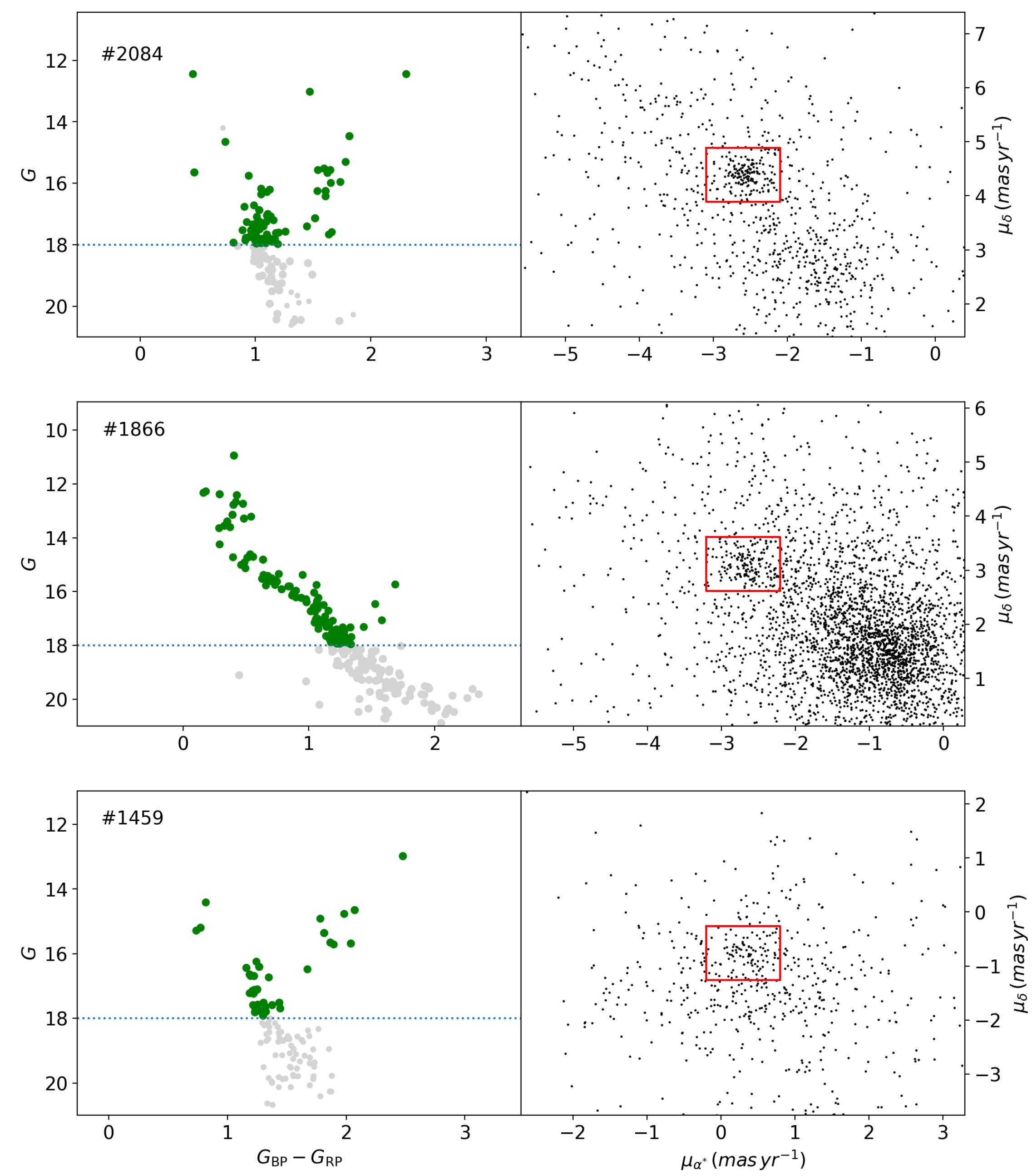

Fig. 2: Color-magnitude diagram for 3 of the candidate clusters. Green dots correspond to stars associated with the overdensity according to our methodology, while below G = 18 we include all objects in the same proper motion range in those spatial pixels. The overdensities are also observed in the proper motion space for most of the candidates (right plots).

JAC-B acknowledges support from FONDECYT Regular N 1220083. KPR acknowledges support from FONDECYT Iniciación 11201161.
S.R.A. acknowledges funding support from the FONDECYT Regular project 1201490.