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Properties of Open Clusters With Gaia DR2

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In this work we explore a new catalog of galactic open clusters containing 1750 clusters that have been re-analysed using the Gaia DR2 dataset to determine the stellar memberships and fundamental parameters such as age, distance, A_V and [Fe/H]. The sample has parameters that are the best determined so far by using improvements in the isochrone fitting procedure such as the use of priors and including an updated extinction polynomial. We present general statistics of the sample like distribution of properties relative to height from the Galactic plane.

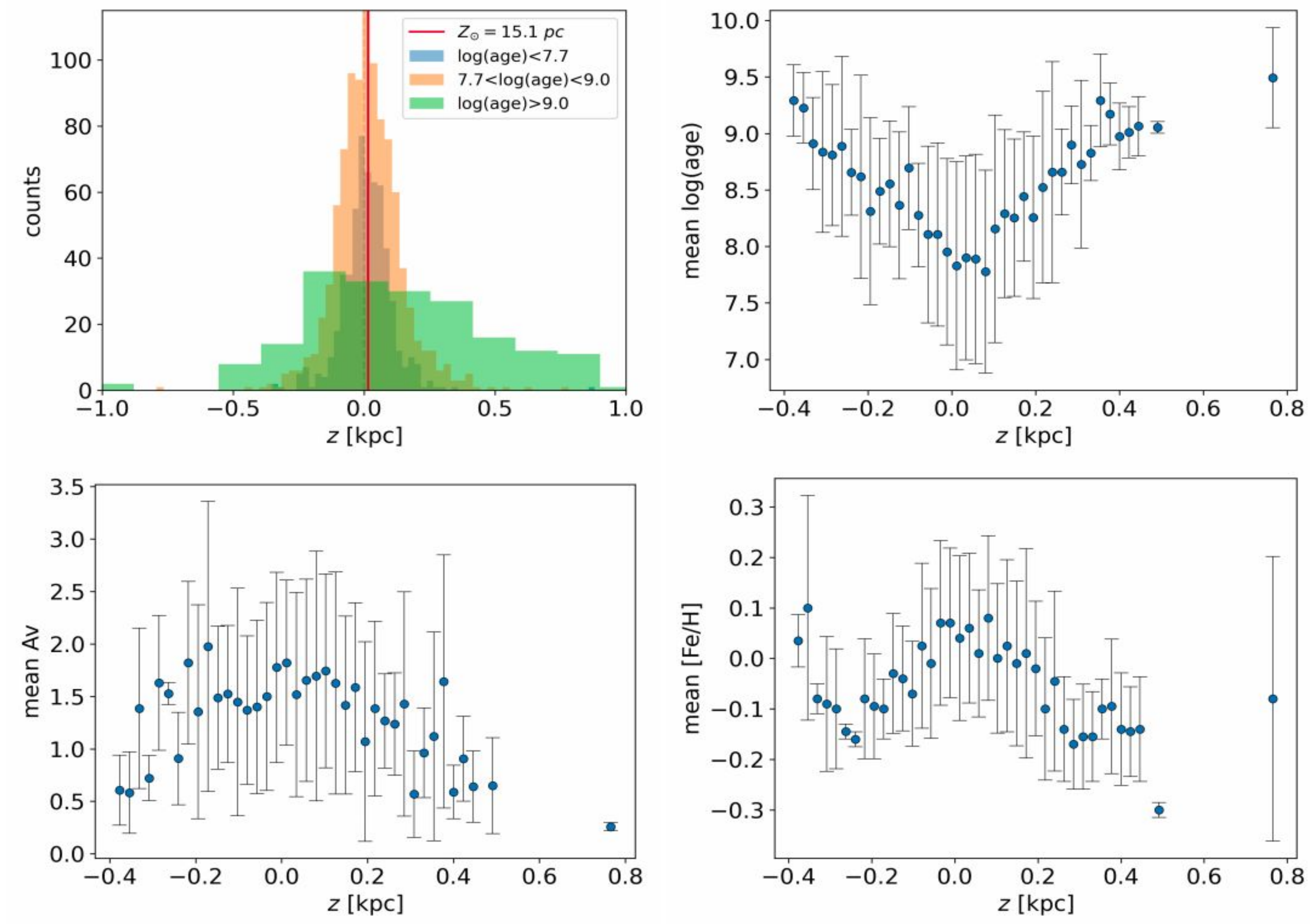

Figure 1: Distribution of the open clusters and their parameters as a function of height relative to the plane of the Galaxy

INTRODUCTION

Open clusters (OCs) are an important class of objects to study a range of astronomical topics, from Galactic structure and dynamics, to the formation, structure, and evolution of stars and stellar systems. Their positions, distances, proper motions and radial velocities, can in general be determined with better precision than those of individual stars, especially for distant objects. Most importantly, with isochrone fitting, their ages can be determined over a broad range with good precision and accuracy.

Before Gaia the most widely used catalogs of OCs and their fundamental parameters were the New catalogue of optically visible open clusters and candidates (Dias et al. 2002b, hereafter DAML) and The Milky Way Star clusters (Kharchenko et al.2013, hereafter MWSC). The Gaia DR2 catalog (Gaia Collaboration et al. 2018a) came with more than 1 billion stars with magnitude G ≤ 21 with high precision astrometric and photometric data, improving the stellar membership determination and characterisation of thousands of open clusters (Cantat-Gaudin et al. 2018; Soubiran et al. 2018a; Monteiro & Dias 2019; Bossini et al. 2019; Carrera et al. 2019;Monteiro et al. 2020). Gaia has also allowed the discovery of hundreds of new OCs (Liu & Pang 2019; Sim et al.2019; Castro-Ginard et al. 2018, 2019, 2020; Ferreira et al. 2020, among others).

In Monteiro et al. (2020) we have focused on the determination of the parameters of 45 difficult clusters, left-overs of previous large scale Gaia based studies. This study introduced methodological improvements to isochrone fitting, including an updated extinction polynomial for the GaiaDR2 photometric band-passes and the Galactic abundance gradient as a prior for metallicity, which led to a successful automatic determination of the fundamental parameters of those clusters. Here we present results obtained from the large scale homogeneous, Gaia DR2 based, sample of 1750 OCs studied with the updated isochrone fitting procedure.

METHODS

The code interpolates on the Padova (PARSEC version 1.2S) database of stellar evolutionary tracks and isochrones (Bressan et al.2012), which uses the Gaia filter passbands of Maíz Apellániz & Weiler (2018), scaled to solar metal content with Z=0.0152. The grid used is constructed from isochrones with steps of 0.05 in log(age) and 0.002 in metallicity.

QUICK FACTS

> **1750** open clusters studied

> Isochrone fits done with a robust global optimization method

> **Priors for Av and [Fe/H]** used in the isochrone fits.

> **Updated** extinction polinomial taking into account the Gaia Passbands.

> **198** new radial velocities determined.

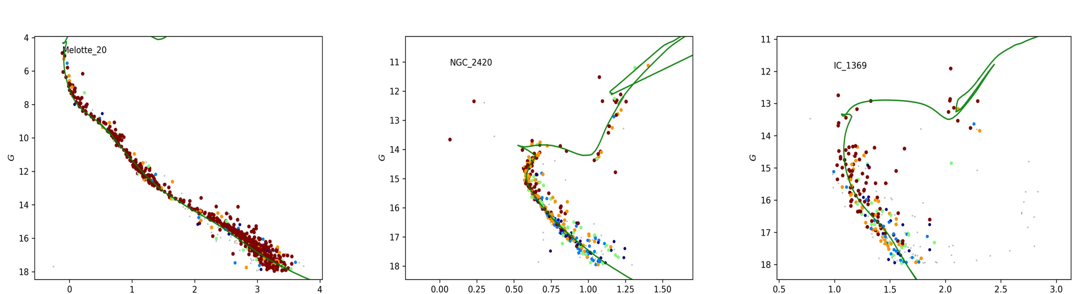

Figure 2: example of isochrone fits performed in Gaia DR2 data

A search for the best solutions is performed in the following parameter space:

- age: from log(age) =6.60 to log(age) =10.15 dex;
- distance: from 1 to 25000 parsec;
- A_V: from 0.0 to 5.0 mag;
- [Fe/H]: from -0.90 to +0.70 dex

To account for the extinction coefficients dependency on colour and extinction due to the large passbands of Gaia filters, we used the most updated extinction polynomial for the GaiaDR2 photometric band-passes, as presented in detail by Monteiro et al. (2020).

RESULTS

> Distribution of fundamental parameters of OCs as a function of height relative to the plane of the Galaxy;

> Isochrone fits for thousands of OCs as shown in Fig. 2;

> Spatial distribution of OCs in the Galactic plane shown in Fig. 3;

> Metalicity gradient and some of the sample properties of [Fe/H] with relation to the log(age) obtained from fits;

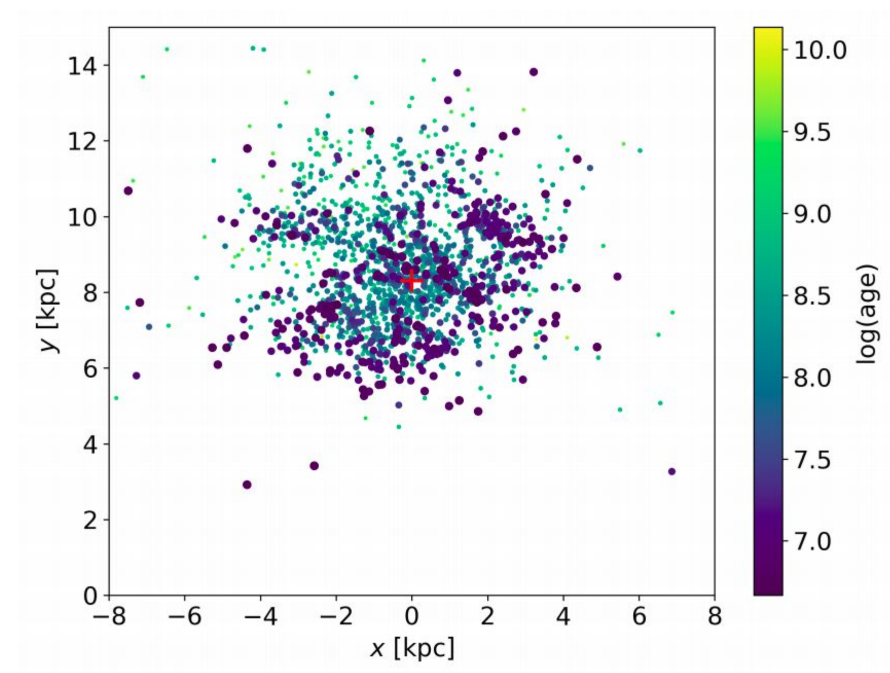

Figure 2: Distribution of the 1750 open clusters in the Galactic plane. In the plot the Sun is at coordinates (0,8.3) kpc and the Galactic center is at (0,0).

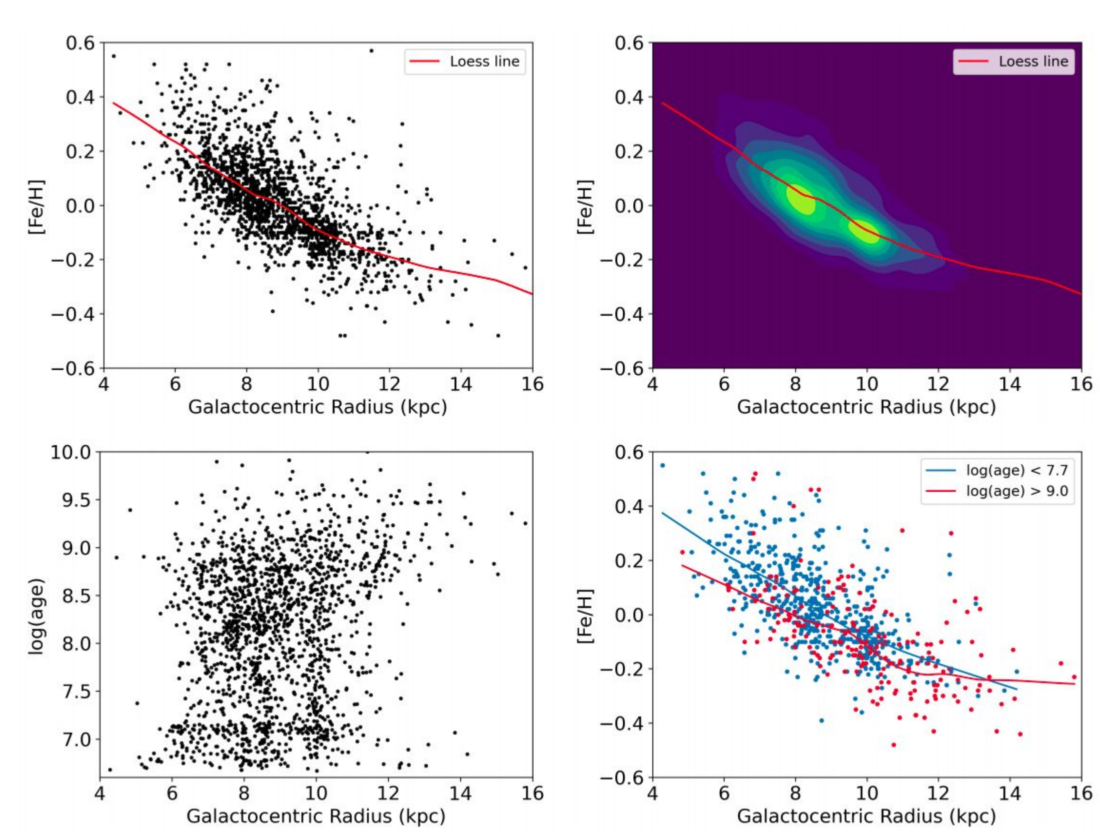

Figure 3: (a) Metallicity [Fe/H] normalized to the Solar value as a function of Galactic radius. In the upper left panel we show all individual points with a non-parametric regression LOESS line over-plotted. In the upper right panel a kernel density estimate in ([Fe/H],radius) space is shown. A gap at 9 kpc can be seen, as well as a slight flattening of the gradient beyond 10 kpc. In the lower left panel the log of the age of the clusters is presented as a function of the Galactic radius, showing a prevalence of old clusters with radii larger than 11 kpc. In the lower right panel the distribution of the old and young population of clusters is shown with their respective non-parametric regression LOESS line over-plotted.

CONCLUSIONS

We presented an update of parameters for 1750 Galactic open clusters from isochrone fits to Gaia DR2 data, using the improved extinction polynomial and metallicity gradient prior as presented in Monteiro et al. (2020), and in addition a weak prior in interstellar extinction. The isochrone fitting code, described in Monteiro et al. (2020,2017) uses a cross-entropy global optimization procedure to fit isochrones to GBP and GRP magnitudes from Gaia DR2 to determine the distance, age, A_V and [Fe/H] of the OCs. The sample is a large homogeneous one that can be used for other studies of Galactic structure and evolution as well as good constraints for stellar evolution in general.

For details of the method and references see:

Monteiro H., Dias W. S., Moitinho A., Cantat-Gaudin T., Lépine J. R. D.,Carraro G., Paunzen E., 2020, MNRAS, 499, 1874