Synergies between Gaia Data Release 2 and OCCASO survey in the study of Open Clusters

Juan Carbajo-Hijarrubia[1]; Laia Casamiquela[2]; Ricardo Carrera[3]; Lola Balaguer-Núñez[1]; Carme Jordi[1]; Friedrich Anders[1]; Sergio Blanco-Cuaresma[4]; Mercè Romero-Gómez[1]; Cristina Chiappini[5]; Elena Pancino[6]
[1]Universitat de Barcelona (ICCUB-IEEC); [2]Laboratoire d'Astrophysique de Bordeaux;
[3]INAF-Osservatorio Astronomico di Padova; [4]Harvard-Smithsonian Center for Astropysics;
[5] Leibniz-Institut fur Astrophysik Potsdam (AIP); [6]INAF-Osservatorio Astronomico di Arcetri

Abstract

Galactic Open Clusters (OCs) are crucial to investigate the formation and evolution of the Galactic disc. The Open Clusters Chemical Abundance from Spanish Observatory survey (OCCASO) aims to provide high precision radial velocity (typical uncertainties between 100 to 200 m/s) and to determine abundances for more than 20 chemical species in around 30 Northern OCs (Casamiquela et al, 2016). We use high resolution (R > 65,000) high signal-to-noise (~70) spectra of at least 6 Red Clump stars for each cluster. In this work we combined Gaia DR2 mean parallaxes and proper motions, and OCCASO radial velocities to obtain 3D spatial velocities and determine the orbits of the clusters. We also study Galactic trends with Galactocentric radius and age of Fe peak and alpha elements for the 18 OCs currently observed in the OCCASO survey, and we compare them with chemo-dynamical models of the Milky Way.

I. INTRODUCTION

Stellar clusters are crucial in the study of a variety of topics including the star formation process, stellar nucleosynthesis and evolution, dynamical interaction among stars, or the assembly and evolution of galaxies. In particular, Open Clusters (OCs) have been widely used to constrain the formation and evolution of the Milky Way disc. They provide information about the chemical patterns and the existence of radial and vertical gradients or an age-metallicity relation.

The Open Clusters Chemical Abundances from Spanish Observatories (OCCASO) survey was designed to study homogeneously a sample of around 30 OCs to obtain precise radial velocities and detailed chemical abundances in order to analyze their kinematics and chemical trends in the Galactic disk.

II. OBSERVATIONS

Observations are distributed in **three instruments** in La Palma and Calar Alto observatories:

- HERMES@Mercator (1.2m) R~85000
- FIES@NOT (2.5m) R~67000
- CAFE@CAHA (2.2m) R~60000

Granted **large program** with **NOT&Mercator**: 5 nights/semester in each telescope until summer 2015. Regular programs since then.

The observational strategy involves:

- **OCs** older than 300 Myr
- **≥6 Red Clump stars** in each cluster
- Signal to noise ratio **SNR≥70**
- **Large range age, Rgc, Z.**

Telescope	NOT	Mercator	2.2mCAHA
Awarded nights	5	11	15
Observed nights	45	45	13
Time lost	30%	17%	50%

III. RESULTS OF THE SURVEY

Spectroscopic analysis completed for 18 OCs, 4 additional clusters were observed during the last year, their analysis is in process.

Radial velocities and spatial velocities analysis published in Casamiquela et al (2016).

Stellar parameters and [Fe/H] abundances published in Casamiquela et al (2017).

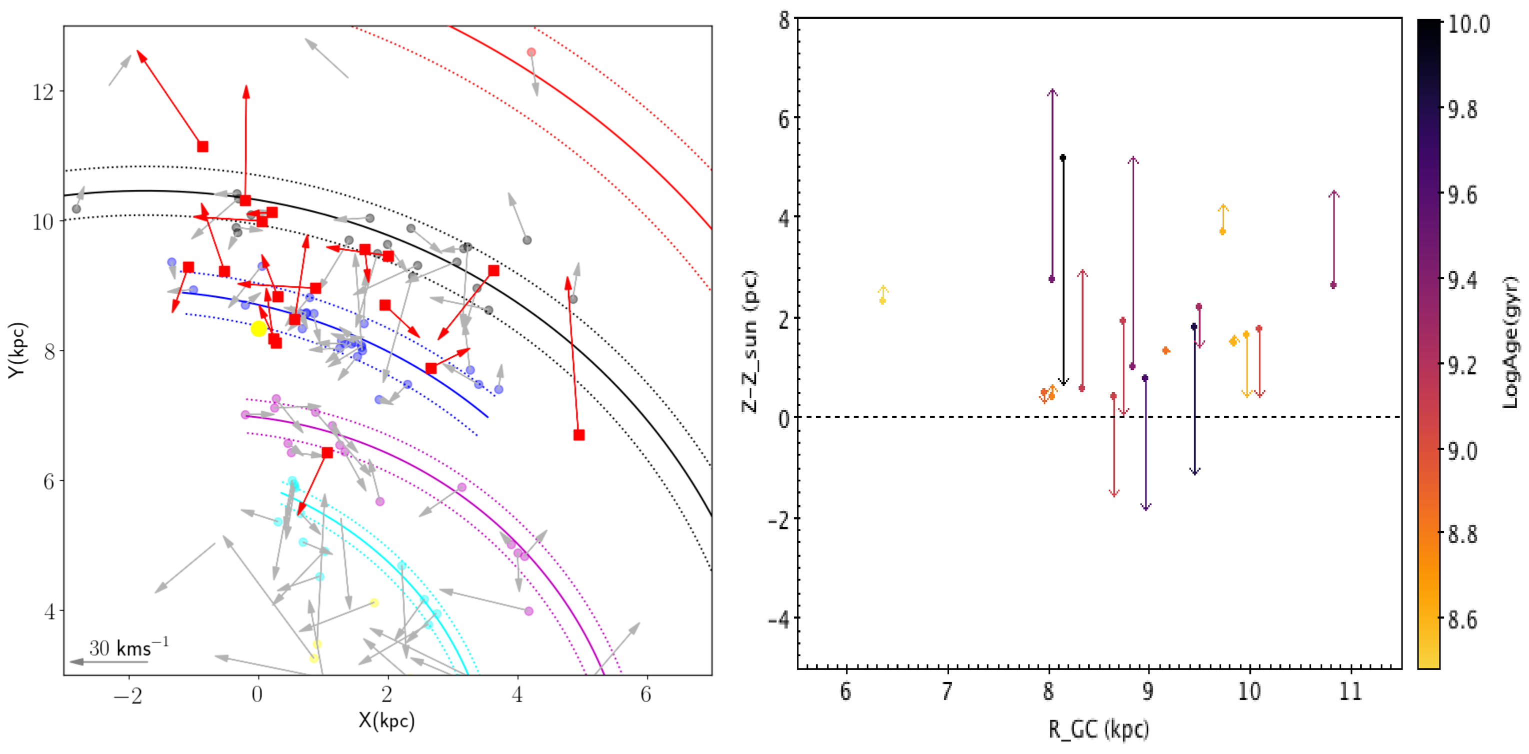
Typical uncertainties of the survey:

- Radial velocities: 100 – 200 m/s
- T_{eff}: 57 K
- log *g*: 0.2 dex
- [Fe/H]: 0.03

Analysis of NGC6705 in Casamiquela et al (2018)

IV. CLUSTER POSITIONS AND VELOCITIES

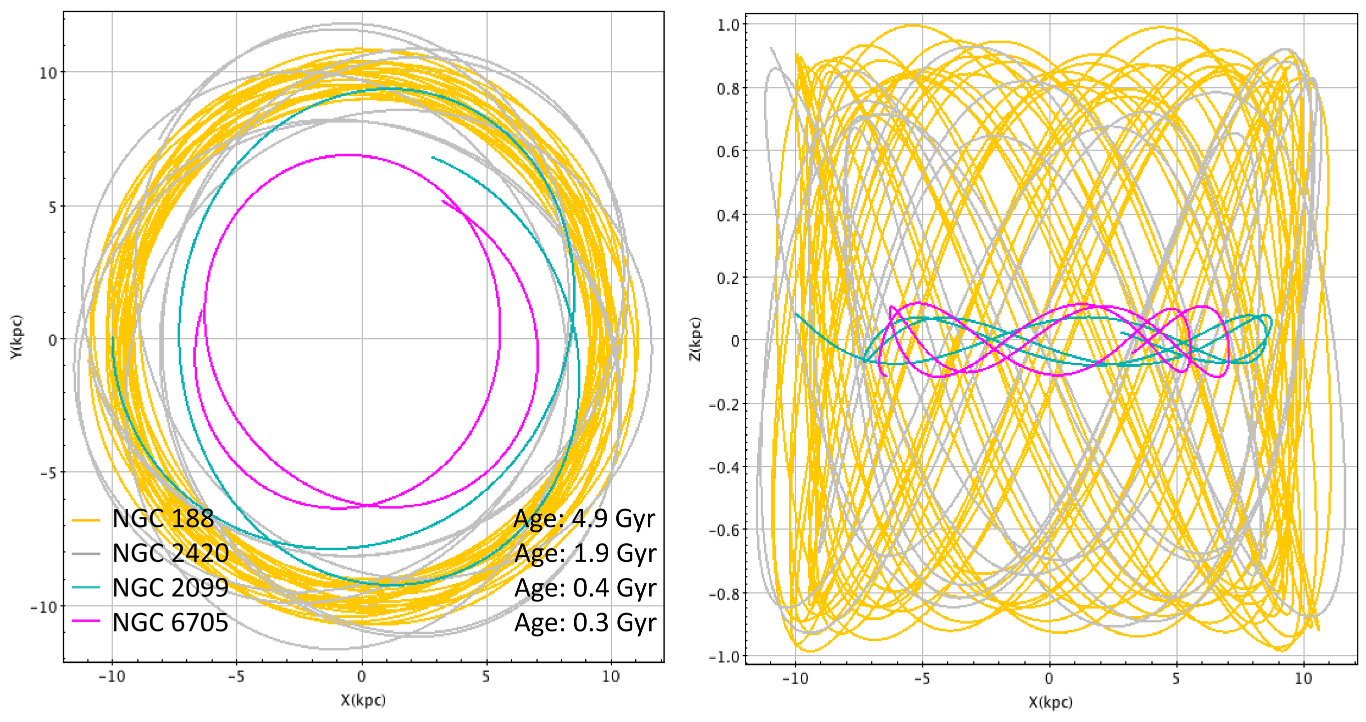
Gaia DR2 mean parallaxes and proper motions and OCCASO radial velocities have been combined to obtain 3D spatial velocities and peculiar velocities with respect to the RSR. The results significantly differ from our previous calculations due to the significant differences with proper motions in Kharchenko et al (2013) and Dias et al (2014).



Left: Spatial distribution (red squares) and velocity (red arrows) of the studied OCs with respect to the spiral arms and the high-mass star forming regions studied in Reid et al. (2014), (in grey). *Right*: The vertical velocity component (arrows) as a function of Galactocentric distance and age.

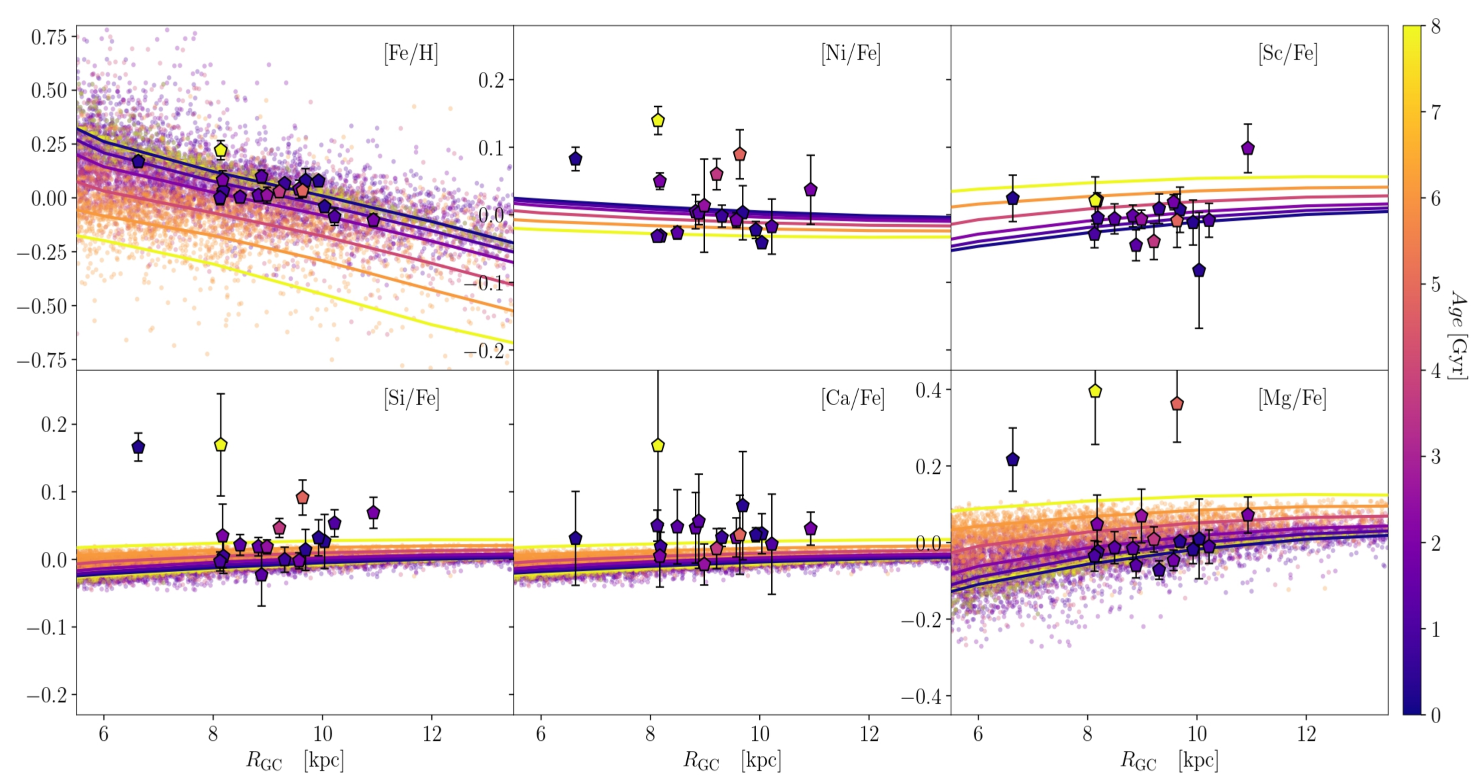
V. ORBIT CALCULATION

The orbits of the OCs have been calculated using a gravitational potential of the Galaxy with two spirals arms and no central bar (Pichardo et al 2003). The assumed mass of the arms is 5% of the mass disc. The arms have a pitch angle of 12 deg and a pattern speed of 30 km/s/kpc.

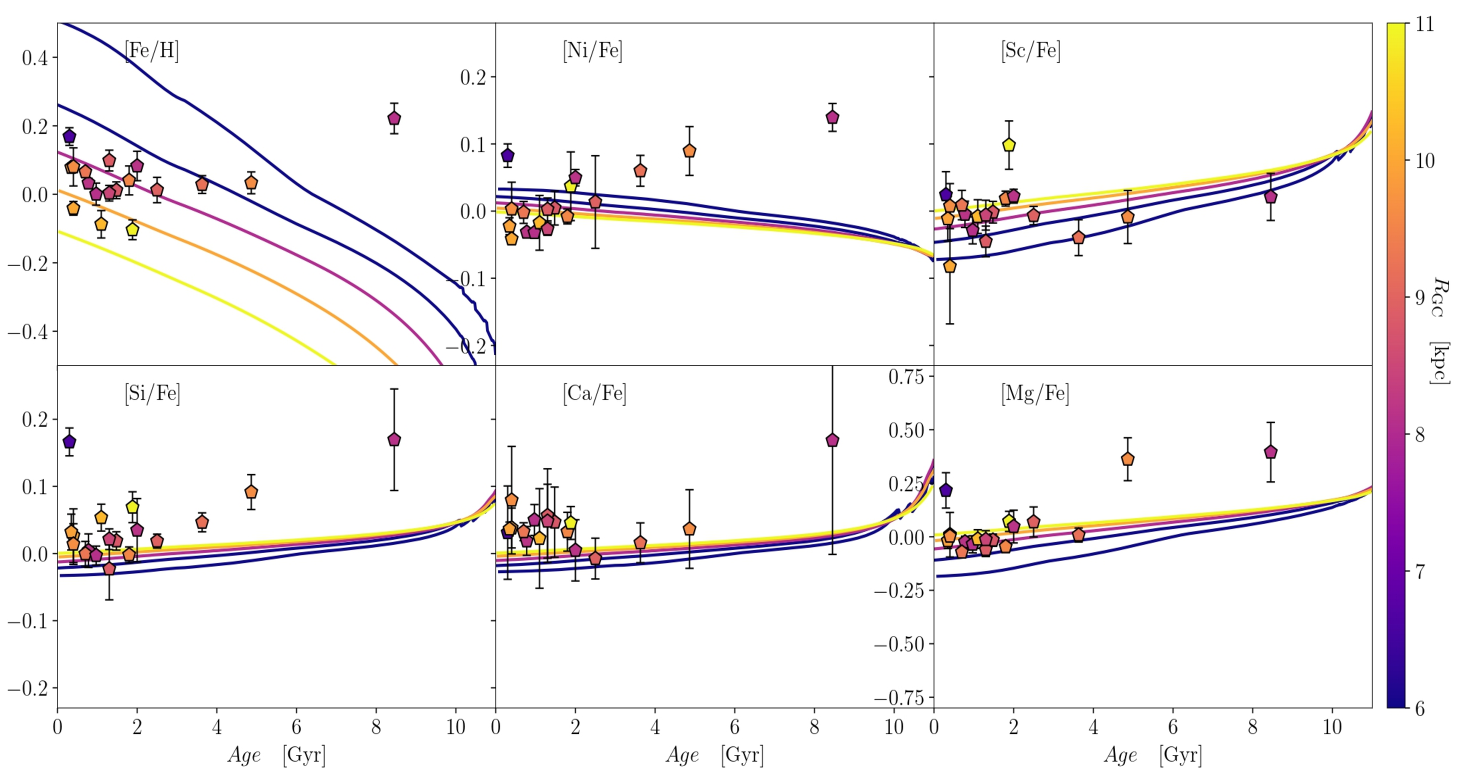


Left: Projection of the orbits onto the Galactic plane for 4 OCs as example. All orbits have very small eccentricities. *Right*: The vertical component for the same OCs. Old clusters reach larger heights above the plane than young OCs, as expected.

VI. CHEMICAL ABUNDANCES TRENDS WITH RGC AND AGE



[Fe/H] and [X/Fe] of the clusters as a function of Galactocentric radius (pentagons colored by age) Casamiquela et al. (2019, submitted), pure chemical evolution models for the thin disk by Chiappini (2009) (colored lines), and N-body chemo-dynamical simulation by Minchev et al. (2014).



Abundance ratios by Casamiquela et al. (2019, submitted), and the pure chemical model predictions as a function of age. The colors correspond to the Galactocentric radii. The resulting slope from the fit is indicated in each panel.

CONTACT

Juan Carbajo Hijarrubia
Universitat de Barcelona, ICCUB-IEEC
e-mail: juan636@fqa.ub.edu

IEEC · Universitat de Barcelona · LAB · Harvard-Smithsonian Center for Astrophysics · INAF Istituto Nazionale di Astrofisica / National Institute for Astrophysics · Osservatorio Astronomico di Padova · AIP Leibniz-Institut für Astrophysik Potsdam