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The OCCASO survey

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Abstract

Open clusters (OCs) are crucial for studying the formation and evolution of the Galactic disc. The lack of a large number of OCs analysed homogeneously hampers the investigations. The OCCASO survey provides homogeneous radial velocities, physical parameters and individual chemical abundances from high-resolution spectroscopy. We present the motivation, current status and first results of the survey for 114 stars in 18 OCs.

1 Introduction

OCs are very suitable targets for studying the disc evolution by analysing chemical composition as a function of position (i.e. radial and vertical gradients), and age. Large high-resolution spectroscopic surveys (R≥20,000) such as APOGEE [6], GES [8], GALAH [12] and WEAVE [4] provide/will provide detailed information about chemical composition, in addition to precise radial velocities. However, GES is the only one that has dedicated observations to OCs, but it only covers the Southern hemisphere. Meanwhile WEAVE is not operational OCCASO is an on-going survey designed to cover the Northern hemisphere. It provides homogeneous radial velocities, atmospheric parameters, and individual abundances of more than 20 chemical species from high-resolution spectroscopy (R≥65,000) of Red Clump stars in Northern OCs.

Up to now, we have completed ∼80% of the observations, which encompass 114 stars in 18 clusters. In our first data release [3] we presented homogeneous radial velocities for 12

OCs. External comparisons have shown differences in radial velocities of individual stars are at the level of 0.1 km s^{-1} (accuracy). We made a dynamical analysis of the 12 presented OCs in the context of the Galactic disc.

The determination of physical parameters and chemical abundances is done using one equivalent width method (DOOp+GALA; [13], [2], [11]) and one synthetic spectral fitting method (iSpec; [1]). In the following, we discuss the results from the analysis of the two methods.

2 Status of the survey

The OCCASO first data release included radial velocities for 77 stars in 12 OCs [3], observed between January 2013 and January 2015. This provided radial velocities for individual stars with precision around 0.5-1 km s^{-1}. A detailed membership study was performed.

After the latest observations in August 2016 we have been able to finish 6 more OCs, which sums up 114 stars in 18 OCs listed in Table 1. With this we can start investigating trends of different elements in the Galactic disc (see Fig. 1).

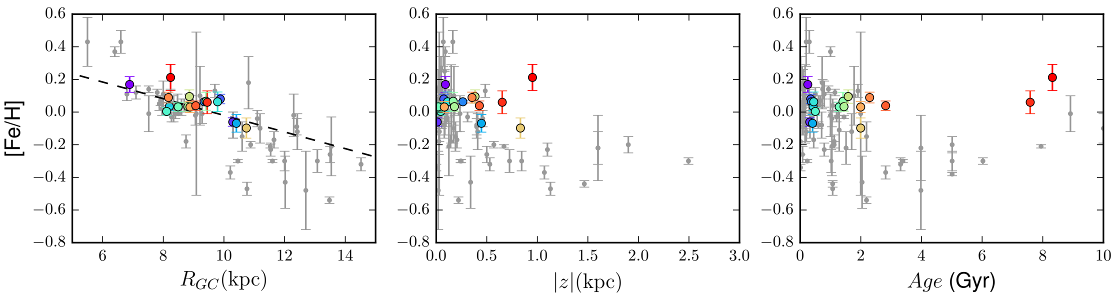

Figure 1: Radial and vertical trends, and age-metallicity relation of 18 OCCASO OCs (color-coded by age) compared to a compilation of determinations from literature (grey). Dashed line in first panel is the gradient derived from Cepheids in [7].

3 Atmospheric parameters and iron abundances

We have determined the atmospheric parameters of the stars: effective temperature ($T_{\rm eff}$), surface gravity ($\log g$), microturbulence (ξ), overall stellar metallicity ([Fe/H]). And the high-resolution and large wavelength coverage of our spectra allow for the determination individual abundances for more than 20 chemical species of the linelist.

We use two approaches to determine atmospheric parameters and abundances: equivalent widths (EW) and spectral synthesis (SS). EWs are determined using DOOp (DAOSPEC) [13], [2] and GALA [11], which optimizes atmospheric parameters using the classical spectroscopic method based on iron lines. As SS method, we use iSpec [1] which compares an

Table 1: Completed clusters of OCCASO. D, z, $R_{\rm CG}$ and Age are derived from [5].

Cluster	D (kpc)	logAge	$R_{\rm CG}$ (kpc)	z (pc)
NGC 188	1.714	9.88	9.45	653
IC 4756	0.484	8.699	8.11	44
NGC 1817	1.972	8.612	10.41	-447
NGC 1907	1.800	8.50	10.29	10
NGC 2099	1.383	8.54	9.88	75
NGC 2420	2.48	9.30	10.74	833
NGC 2539	1.363	8.57	9.35	263
NGC 2682	0.808	9.45	9.07	427
NGC 6633	0.376	8.63	8.20	54
NGC 6705	1.877	8.40	6.89	-91
NGC 6791	5.035	9.92	8.24	952
NGC 6819	2.403	9.36	8.17	354
NGC 6939	1.80	9.20	8.86	384
NGC 6991	0.70	9.11	8.49	20
NGC 7245	3.467	8.65	9.79	-112
NGC 752	0.457	9.16	8.81	-180
NGC 7762	0.78	9.30	8.88	80
NGC 7789	1.795	9.15	9.41	-168

observed spectrum with synthetic ones generated on-the-fly, and minimizes the difference between them using a least-square algorithm.

Both methods use the same model atmospheres (MARCS; [9]), and the same linelist from the Gaia-ESO survey [10]. $T_{\rm eff}$ and $\log g$ derived from both methods are compatible within the errors, and show no remarkable systematic differences (see Fig. 2). When averaging results of atmospheric parameters, both methods derive compatible iron abundances.

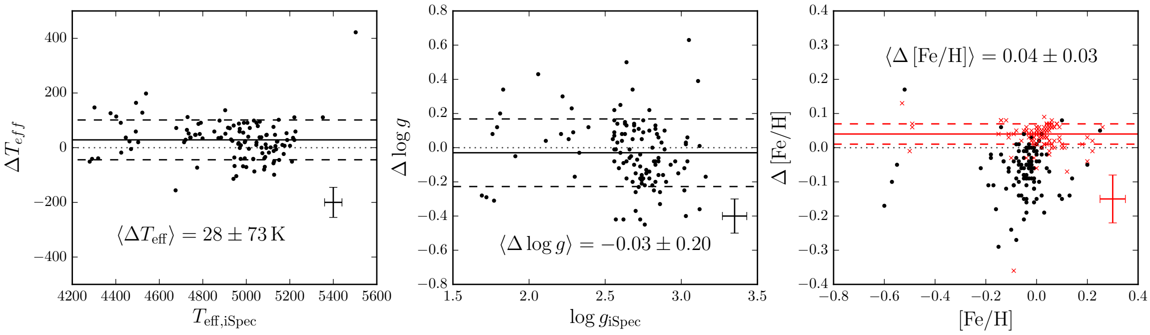

Figure 2: Differences in $T_{\rm eff}$ (left), $\log g$ (middle) and [Fe/H] (right) between GALA and iSpec. Right panel: abundances determined when each method uses its own atmospheric parameters (black dots); and when atmospheric parameters are fixed to the average (red crosses). Solid lines: mean difference; dashed lines: 1σ level.

3.1 Mean iron abundances

By fixing atmospheric parameters to the mean values derived from the two methods, we have obtained mean cluster abundances of more than 20 chemical species. In particular, results for iron in a subsample of OCs are shown in Fig. 3 as an example of the quality of the results. Dispersions inside the same cluster are 0.01-0.07 dex.

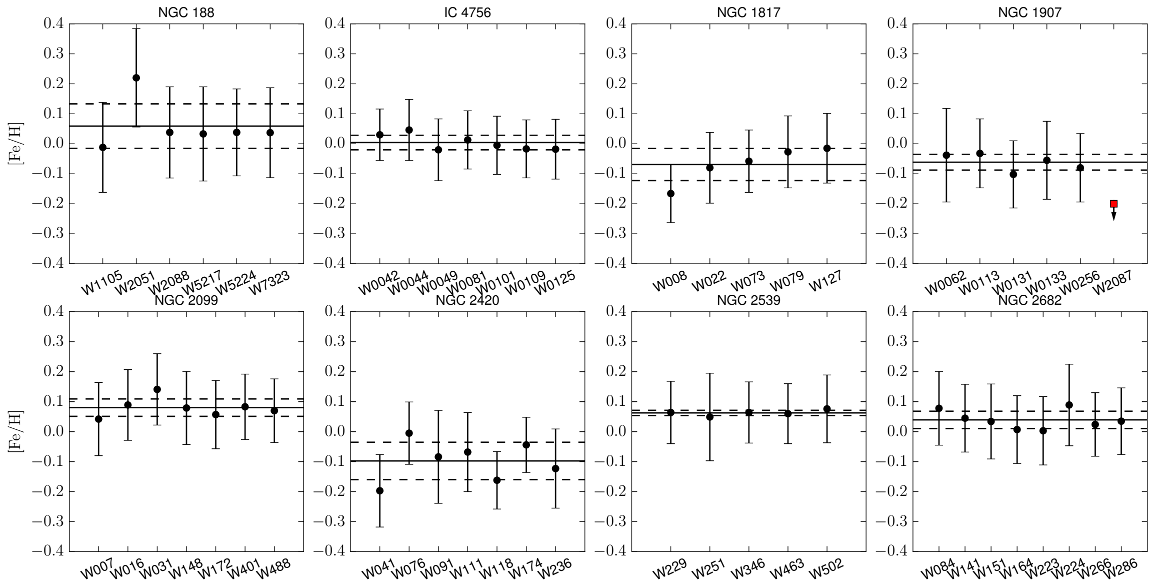

Figure 3: An example of iron abundance results of 8 clusters among the 18 OCs. Red square indicate a probable non member or spectroscopic binary detected by [3]

4 Conclusions

The OCCASO survey has completed the analysis of 18 OCs by August 2016. Radial velocities, atmospheric parameters and chemical abundances have been derived after a detailed comparison of the results that EW and SS derive. Both methods give consistent results after a proper line selection, and iron abundances get compatible when average $T_{\rm eff}$ and $\log g$ are used. Results show no systematic differences with literature. Among the 18 OCs, our sample includes several OCs never studied before with high resolution spectroscopy (NGC 1907, NGC 6991, NGC 7762), and other very interesting metal-rich OCs (NGC 6705, NGC 6791).

Acknowledgments

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