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Using open clusters as tracers of the galactic disk history

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Abstract. Open clusters are important objects to study the galactic structure and its dynamical behavior as well as the stellar formation and evolution. We carried out a spectroscopic analysis to derive atmospheric parameters and chemical composition for 52 giant stars within 9 galactic open clusters. We have used the high-resolution spectra from FEROS, HARPS and UVES in the ESO archive. The methodology used is based on LTE-hypothesis. Abundances of C, N, O, Na, Mg, Al, Si, Ca, Ti, Cr, Ni, YII, LaII, CeII, and NdII were calculated. Although most of these clusters present spectroscopic analysis in the literature, some CNO and s-process abundances were not previously estimated or were calculated with high uncertainties. Several lines of such elements were identified and used to calculate new abundances and improve some previous one.

Keywords. stars: abundances – open clusters and associations: general – stars: evolution

1. Our sample and methodology

Because of their location at different galactocentric distances, open clusters are excellent targets to define radial gradients of metallicity and chemical abundances which determine the disk structure of the Galaxy. They are also found in a wide range of ages making older clusters important to unveil the thick disk. In this project we have started by analyzing 52 G F K giant stars within 9 open clusters listed in Table 1. The high resolution spectra were obtained from ESO archive. The stars were observed with the FEROS, HARPS and UVES spectrographs. We selected spectra with $S/N \geqslant 150$ in order to obtain reliable abundances. The stellar atmospheric parameters and chemical abundances were obtained using the LTE hypothesis and the Kurucz atmospheric grids. The abundances of CNO elements were obtained through spectral synthesis technique. Abundances of Iron-peak, alpha and heavy-elements were obtained from equivalent widths. To avoid the dependency on the log gf, we applied a line by line analysis relative to Juno solar spectrum such as in Katime Santrich & Rossi (2017).

2. The abundance pattern

The stellar atmospheric parameters are in the ranges: T_{eff}=[4435, 5575]K; log g=[1.62, 3.57]dex; ξ=[1.12, 4.25]Km/s; [Fe/H]=[-0.32, 0.28]dex whereas the ranges of the abundance ratios for the Iron-peak and alpha elements are: [Na/Fe]=[-0.05, 0.37]dex; [Mg/Fe]=[-0.18, 0.31]dex; [Al/Fe]=[-0.19, 0.31]dex; [Si/Fe]=[-0.12, 0.24]; [Ca/Fe]=[-0.09, 0.29]; [Ti/Fe]=[-0.19, 0.09]dex; [Cr/Fe]=[-0.07, 0.04]dex and [Ni/Fe]=[-0.14, 0.11]dex. Figure 1 shows the abundance ratios for CNO elements (left) and the heavy-elements (right). The majority of the stars analyzed in this work are in RGB phase and some objects are subgiant stars. In general, all abundances overlap the galactic chemical evolution

Table 1. Clusters analyzed in this work. V_r^a and V_r^b are the radial velocities found by us and Mermilliod *et al.* (2008) respectively. V_r^a were obtained from Doppler shift of the absorption lines.

Star	α	δ	V_r^a (Km s^{-1})	V_r^b (Km s^{-1})	R_{gc} (KPc)	Ages (GYr)	N_{stars}
NGC 3960	11 50 33	−55 40 24	-20.75 ± 2.56	-22.26 ± 1.13	7.21	0.66	5
NGC 5316	13 53 57	−61 52 06	-13.47 ± 2.00	-15.10 ± 0.55	9.38	0.15	4
NGC 6259	17 00 45	−44 39 18	-31.67 ± 2.14	-34.66 ± 2.30	8.55	0.22	4
NGC 6281	17 04 41	−37 59 06	-4.59 ± 1.88	-5.58 ± 0.37	8.40	0.31	5
IC 4651	17 24 50	−49 56 00	-29.58 ± 0.85	-30.98 ± 0.49	8.53	1.14	7
NGC 6633	18 27 31	+06 34 12	-28.16 ± 1.75	-28.95 ± 0.23	8.48	0.43	6
IC 4725	18 31 47	−19 07 00	$+3.06\pm0.58$	$+2.72\pm0.23$	8.57	0.09	2
IC 4756	18 38 31	+05 29 24	-24.10 ± 1.07	-25.16 ± 1.10	8.45	0.79	14
NGC 6705	18 51 05	−06 16 12	$+34.93\pm1.79$	$+35.08\pm1.23$	7.55	0.20	5

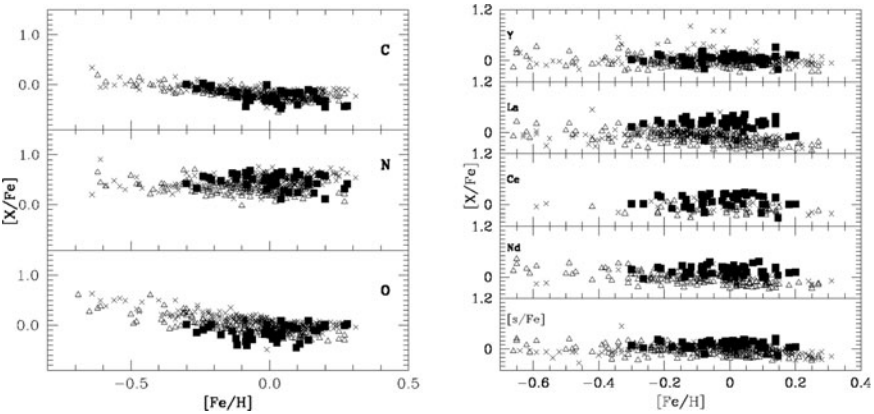

Figure 1. CNO and s-process abundances for the giant stars studied in this work. Fiel giants are represented by triangles (Mermilliod *et al.* 2008) and crosses (Luck & Heiter 2007). Our cluster giants are represented by fill squares. The maximum uncertainty for CNO abundances is 0.05 dex whereas for s-process abundances is 0.03 dex.

trend. However, there are elements like La and Nd that show a trend to be more abundant in cluster giants than in the field. Our differential analysis obtained abundances with less uncertainties than in literature. We have found several lines of Zirconium, Praseodymium, Samarium and Europium which are being studied to calculate the respective abundances. We did not find any chemical anomalies in our sample stars. At the same time, there are some binary candidates that are being analyzed. Comparissons between our abundance spread and the ISM are being studied. All these results will be published in a following paper.

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