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Oxygen abundances in thin and thick disk stars from HARPS

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Abstract. We present a detailed and uniform study of oxygen abundances in a large sample of solar-type stars. EW measurements were carried out for the [OI] 6300 Å and the OI 6158 Å lines and LTE abundance results for these indicators were obtained in 611 and 535 stars respectively. 411 stars have oxygen derived from both indicators, which allows us to perform the first uniform comparision of these two oxygen indicators in a large sample of stars. We found that 65% of the stars yield abundances that agree within 0.1dex, and this result improves for better values of signal-to-noise. We also have studied the oxygen trends for different galactic populations. We confirm an oxygen enhancement for stars belonging to the thick disk, as it has been seen also for other alpha elements.

Key words. Stars: abundances – Galaxy: abundances

1. Introduction

After hydrogen and helium, oxygen is the most abundant element in the Universe. Interstellar medium is enriched with oxygen by Type II supernovae and together with iron, which is produced in both Type II and Type Ia supernovae, is used as a record of galactic chemical enrichment. Therefore, measuring element abundances in the atmospheres of late-type stars provides a trace of chemical history of the different stellar populations in our Galaxy.

The number of atomic lines of oxygen suitable for abundance analysis in the optical or near infrared spectra is small. Most of the previous works on oxygen with large samples of stars (e.g. Bensby et al. 2004; Ecuvillon et al. 2006; Delgado Mena et al. 2010; Petigura & Marcy 2011) are based on two indicators: OI triplet at ~7774Å and [OI] at 6300Å. Ecuvillon et al. (2006) used in addition four near-UV OH lines. However, all these lines present difficulties in their analysis. Triplet lines are strongly affected by deviations from LTE (e.g. Caffau et al. 2008) while the forbidden line is often blended with telluric lines and contains a NiI blend at 6300.399Å (e.g. Lambert 1978; Allende Prieto et al. 2001). In addition, disagreement betwen both indicators in metal poor giants can reach up to 1dex (Israelian et al. 2004). This makes the determination of oxygen abundances still an unclear issue.

Our work presents a complete and uniform study of the oxygen abundances in a large sample of stars using two different indicators: the

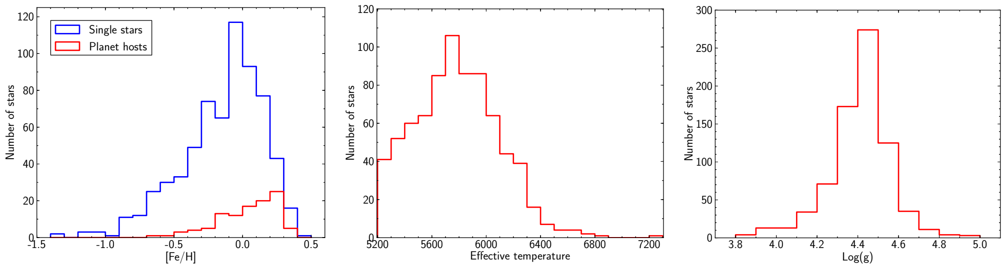

Fig. 1. Distribution of the stellar parameters in our sample.

already mentioned oxygen forbidden line at 6300Å and the high excitation 6158Å line.

2. Sample description and stellar parameters

The sample of 762 stars used in this work is a combination of three subsamples: HARPS-1 (Mayor et al. 2003), HARPS-2 (Lo Curto et al. 2010) and HARPS-4 (Santos et al. 2011). The stars were selected to have temperatures higher than 5200K. Fig. 1 shows the distribution of stellar parameters. The combined spectra of each star have a resolving power R~115000 and signal-to-noise (S/N) between ~40 and ~2000. About 90% of stars have S/N higher than 100. Such a high quality data allows us to measure the 6158Å line in a large sample of stars and investigate its reliability as an oxygen indicator.

Precise stellar parameters were determined by Sousa et al. (2011a,b) using the same spectra as we did for this study. The typical precision uncertainties are of about 30 K for Teff, 0.06 dex for logg, 0.08 km s^{-1} for ξ_t, and 0.03 dex for [Fe/H].

3. Abundance analysis

Abundance ratios were derived using two different indicators: the forbidden line at 6300Å and the 6158Å line. EW measurements were carried out for both lines in a detailed analysis using splot package from IRAF (Tody 1993). Due to the presence of telluric lines in the vicinity of [OI] line, we made a thorough observation of the spectra in this region to account for possible blends.

Table 1. Atomic parameters of the oxygen lines

Element	λ [Å]	log gf	χ_{lo} [eV]	Ref.
O	6158.1	-0.296	10.74	1
O	6300.3	-9.717	0.00	1
Ni	6300.4	-2.310	4.27	2

1: Caffau et al. (2008)
2: Allende Prieto et al. (2001)

LTE abundances for all indicators were determined according to a standard analysis with the revised version of the spectral synthesis code MOOG2013 (Sneden 1973) and a grid of Kurucz ATLAS9 plane-parallel model atmospheres (Kurucz et al. 1993). Ni blend contribution to the EW of [OI] was estimated using the ewfind driver of MOOG and Ni abundances from Adibekyan et al. (2012). The adopted solar abundances were $log\epsilon(O)_\odot$ = 8.74 (Nissen et al. 2002) and $log\epsilon(Ni)_\odot$ = 6.25 (Anders & Grevesse 1989). Parameters of spectral lines are listed in table 1. NLTE corrections for OI 6158Å are negligible (e.g. Caffau et al. 2008).

4. Galactic trends

We adopted a purely kinematical approach to separate different stellar populations based on Bensby et al. (2003) criteria. We refer the reader to Adibekyan et al. (2011) for further details about the derivation of space velocity components on HARPS sample. Abundance trends in the thin and thick disks are presented in Fig.2. Oxygen, as other α-elements, is enhanced relative to iron for thick disk stars. Although [O/Fe] is decreasing with increasing [Fe/H], there is a clear change in the slope at

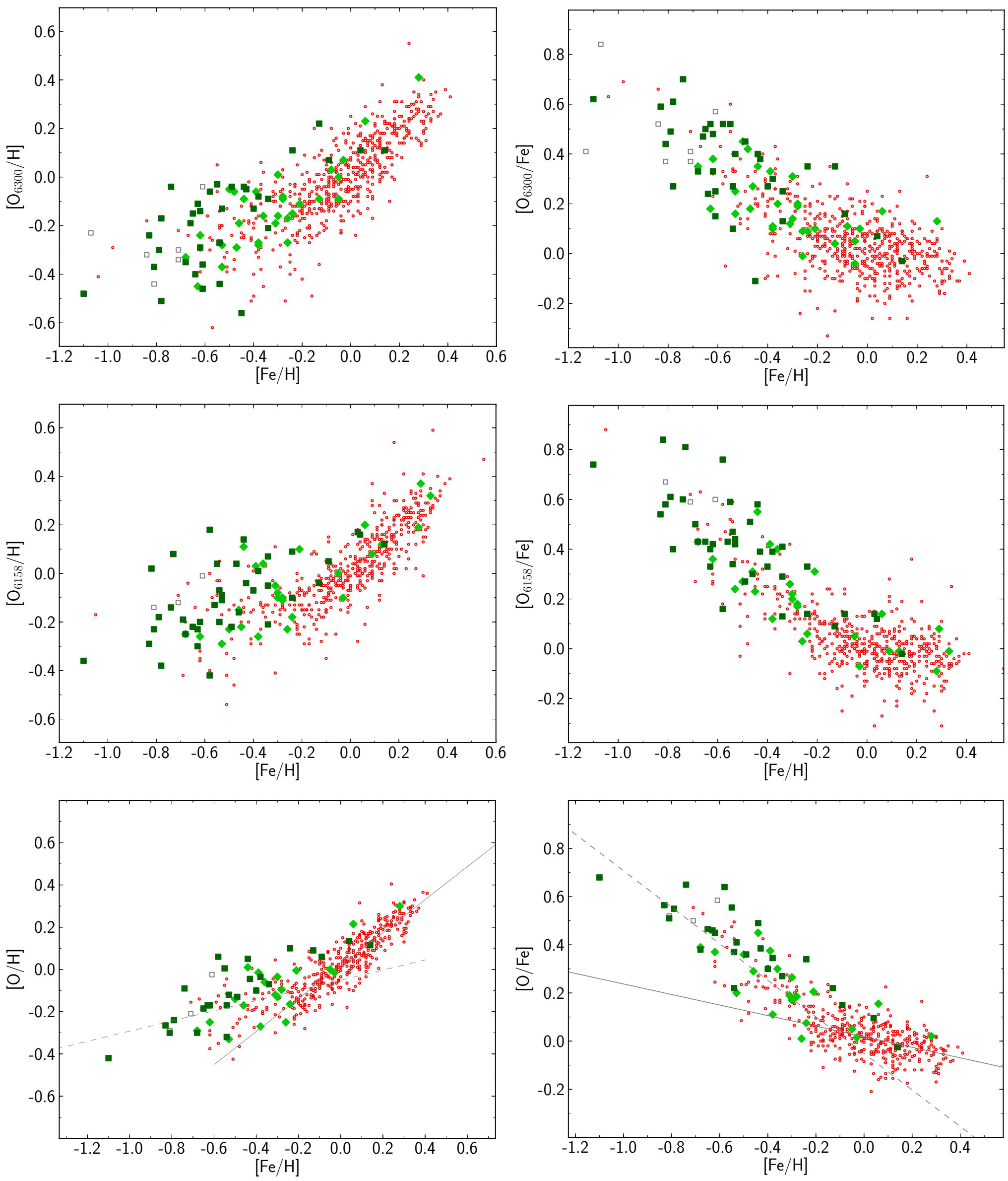

Fig. 2. [O/H] and [O/Fe] against [Fe/H] for the two indicators ([OI] 6300Å and OI 6158Å at the top and middle panels respectively) and for the average value at the bottom. Open circles represent thin disk stars, filled diamonds are transient stars, filled squares refer to stars from the thick disk and open squares are stars belonging to the halo. Linear fits for [Fe/H]>-0.2 and [Fe/H]<-0.2 are presented.

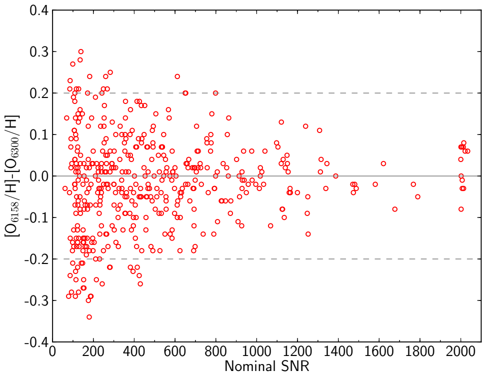

Fig. 3. Diference between [O/H] derived from two oxygen indicators, as a function of S/N ratio.

[Fe/H]~-0.2. This discontinuity appears even if we only consider stars from the thin disk, therefore, is not related to the lower metallicity and enhanced oxygen abundance of the thick disk popullation.

5. Comparision between indicators

Abundances from [OI] line at 6300Å were obtained in 611 stars, while 535 stars were analysed using the OI at 6158Å. 411 out of the initial sample of 762 stars have oxygen measurements from both lines. Altogether we present oxygen abundances for 735 stars.

Figure 3 shows the comparison between the results obtained form both oxygen indicators. The agreement between indicators is better than 0.1dex for 65% of the stars with measurements of both lines. The improvement of the signal-to-noise yields lower discrepancies. However, due to the intrinsic errors of the procedure, and specially due to the uncertainties coming from the continuum placement, discrepancies reach 0.1 dex regardless of the signal-to-noise.

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