Oxygen abundances in metal-poor subgiants

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Abstract. There seems to be no consensus on the [O/Fe] values found in metal-poor stars nor their trend with metallicity: different indicators give different results. We present here [O/Fe] derived from three different oxygen abundance indicators ([O I], O I and OH UV lines) for a sample of thirteen subgiant stars with metallicities in the range $-3 \leqslant$ [Fe/H] $\leqslant -1.5$. Oxygen and iron abundances were determined from the analysis of high S/N spectra acquired with the UVES spectrograph at VLT. We found good agreement between [O/Fe] estimates based on OH and the estimates based on [O I] (mean difference $\sim -0.09 \pm 0.25$(s.d.)), although the scatter is not insignificant. Unfortunately, good agreement is not reached for the third indicator (mean difference $\sim 0.19 \pm 0.22$(s.d.)). Our [O I] and OH-based estimates do not show a well defined linear trend with metallicity. Another interesting result is that the abundances based on molecular lines ([O/Fe] ~ 0.45) are in general lower than previous published results for turn-off stars even though a lower solar oxygen abundance (A(O) = 8.74) was assumed.

**Keywords.** Line: formation, stars: abundances, stars: Population II, galaxy: evolution

1. Introduction

Oxygen is produced in stars by nuclear reactions and then ejected into the interstellar medium by supernovae from where new generations of stars are born. The surface composition of these stars will remain unchanged until their stellar atmospheres undergo mixing processes or suffer pollution, etc. Being oxygen one of the main input parameters of any galactic chemical model, oxygen abundances in turn-off or subgiant stars provide important clues to better characterise the chemical evolution of the Galaxy. The knowledge of these abundances is also very useful to further constrain the physics behind cosmic-ray spallation reactions and our understanding of light element evolution.

However, oxygen abundances in metal-poor stars have been a subject of debate for the last two decades and no consensus for their values nor their trend with metallicity has been reached so far (Barbuy 1988; Israelian, García López & Rebolo 1998; Nissen, Primas, Asplund & Lambert 2002). Differences between the indicators have been investigated in terms of systematic errors: 3D and/or NLTE abundance effects (Asplund & García Pérez 2001) and $T_{\rm eff}$-scale. Whether the observed differences are because different indicators are used in different type of stars or because of systematic errors can be disentangled

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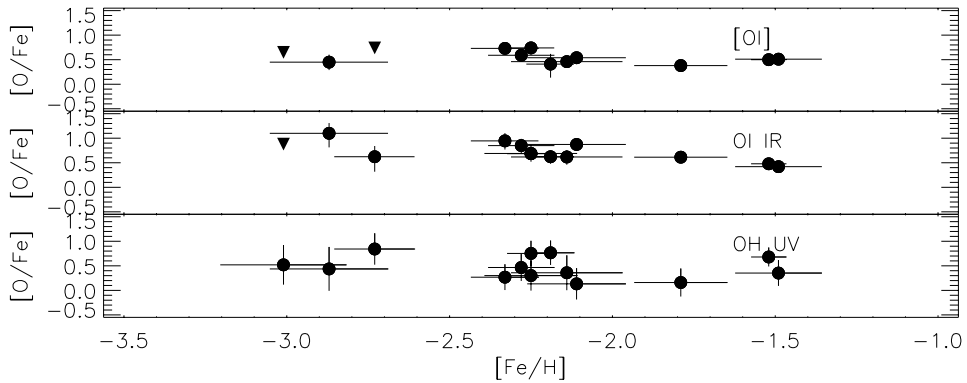
Figure 1. [O/Fe] estimates as a function of metallicity. Estimates based on different indicators are shown separately: [O I] (top panel), O I(middle panel) and OH (bottom panel).

with an homogeneous study of a sample of stars for which all the abundance indicators can be used. Here we present such study, i.e. the analysis of O I line at 630.03 nm ([O I]), O I triplet lines at 777.1–5 nm (O I) and nine OH lines around 310.0 nm (OH) in thirteen subgiant stars.

2. Oxygen abundances over iron abundances

Our oxygen and iron abundances determinations are based on the use of high resolution and high S/N (500 in the optical, 250 in the near-IR and 100 in the near-UV) VLT/UVES spectra. The analysis of these spectra was carried out in 1D-LTE and using MARCS model atmospheres with stellar parameters derived from: for effective temperatures, $(b - y)$ and $(V - K)$-vs-T_{eff} calibrations based on the infrared flux method; for surface gravities, Hipparcos parallaxes and isochrones; and for metallicity, thirteen Fe II lines. Oxygen abundances derived from the O I lines were corrected for NLTE effects.

Our [O/Fe] estimates (~ 0.45) based on the molecular lines give values much lower than previously published results for turn-off stars (Israelian, García López & Rebolo 1998), hence they are more in accordance with our [O I]-based estimates (mean difference $\sim -0.09 \pm 0.25$(s.d.)). On the contrary, the O I-based estimates are somewhat different with a mean difference of -0.19 ± 0.22(s.d.) with respect to [OI]-based estimates (cf different panels in Fig. 1). We should not and must not neglect the fact that for both cases the standard deviation in the differences is not insignificant. A possible explanation for that scatter may be the presence of systematic effects (3D and/or NLTE effects, the assumption of a wrong assumed T_{eff}-scale) some of which we have tried to minimise using subgiant stars. Concerning the [O/Fe]-vs-[Fe/H] trend at low metallicity, a linear trend is not so well defined except for the case of the indicator O I.

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