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Oxygen Abundances in Ultra-metal-poor Giants CS29498-043 and CS22949-037

G. ISRAELIAN[1], N. SHCHUKINA[2], R. REBOLO[1,3], G. BASRI[4],
and J. I. GONZÁLEZ HERNÁNDEZ[1]
(1)Instituto de Astrofísica de Canarias, La Laguna 38200, Tenerife, SPAIN
(2) Main Astronomical Observatory, National Academy of Sciences, 03680 Kyiv-127, UKRAINE
(3) Consejo Superior de Investigaciones Científicas, SPAIN
(4) Astronomy Department, University of California, Berkeley, California 94720, USA

Abstract
Abundances of oxygen in two ultra-metal-poor giants have been derived from measurements of the oxygen triplet at 7771-5 Å in the near-IR performed in high-resolution and high S/N ratio spectra obtained with KeckI/HIRES. A detailed non-LTE analysis of Fe lines has been carried out for our targets providing more reliable stellar parameters and metallicities.

1.1 Introduction

The most metal-poor stars in our Galaxy contain the material ejected from the first generation supernova. First detailed analysis of CS22949-037 by McWilliam et al. (1995) confirmed that this star is very metal-poor with alpha-element excess. Furthermore, Depagne et al. (2002) found a large excess of oxygen ([O/Fe]=+2.0) and sodium [Na/Fe]=+2.1. Zero-heavy-element supernovae models with fallback have been involved in order to explain abundances in this star. More recently, Aoki et al. (2002) discovered another ultra-metal-poor giant CS29498-043 with very high abundance excess of [Mg/Fe]=1.81. Both, CS22949-037 and CS29498-043 exhibit large overabundance of N and C. The detailed comparison of elemental abundances in these stars may provide important constraints on the properties of the first supernova progenitors.

1.2 Observations

The observations were performed in October 2002 at the KeckI (Hawaii) with the high-resolution spectrograph HIRES and the TEK 2048$\times$2048 pixel^2 CCD. A 1.1 arcsec entrance slit yielded a resolving power 60.000. A red wavelength setting was used to observe oxygen triplet lines. The average signal-to-noise ratio near the triplet was close to 100. Additional spectra of CS29498-043 obtained with TNG/SARG (La Palma) in September 2002 confirmed the presence of the oxygen triplet.

1.3 Analysis

Models of atmospheres of Kurucz (1992) were used to analyze the spectra of the giants. Equivalent widths of Fe lines in CS29498-043 and CS22949-037 were taken from the articles of Aoki et al. (2002) and Depagne et al. (2002), respectively. NLTE analysis

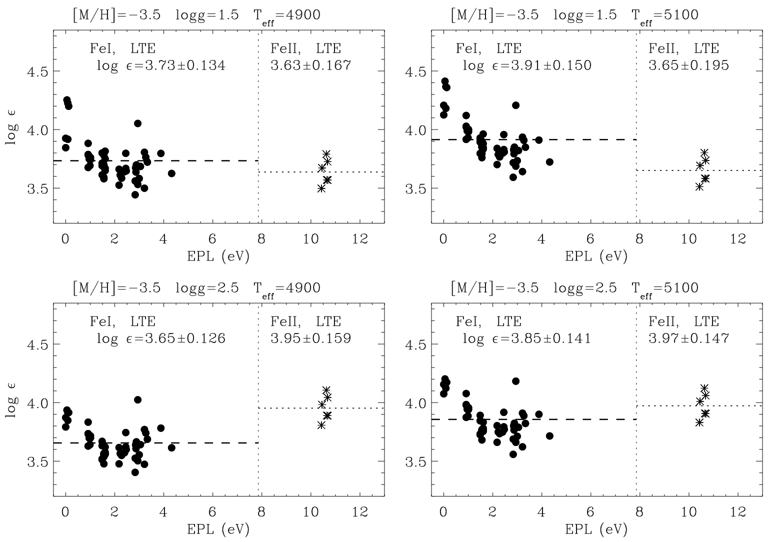

Fig. 1.1. Results of LTE Fe abundance determination for Fe I and Fe II lines in CS22949-037 for a small grid of model atmospheres.

of Fe was carried out with the code NATAJA (Shchukina & Trujillo Bueno 2001) and the atmospheric parameters were derived using the same method as in Israelian et al. (2001). NLTE computations of the oxygen atom were carried out using the updated 23 level model atom described by Shchukina (1987).

Figures 1.1, 1.2 and 1.3 show our computations for a small grid of model atmospheres for CS22949-037. Final atmospheric parameters of CS22949-037 are $T_{\rm eff}$=4900 K, $\log g$=2.5 and [Fe/H]=-3.5. Similar computations were carried out for CS29498-043 for which we obtained $T_{\rm eff}$=4300 K, $\log g$=1.5 and [Fe/H]=-3.5. Thus, the gravities obtained by us are about 1 dex larger than those reported by Aoki et al. (2002) and Depagne et al. (2002).

We have detected all three lines of the oxygen triplet in CS22949-037 and CS29498-043 (Fig 1.4). The NLTE corrections ($\Delta\epsilon = \epsilon(NLTE) - \epsilon(LTE)$) to the oxygen abundance derived from the triplet were 0.18 (CS29498-043) and 0.22 (CS22949-037). Our NLTE oxygen abundances yield very high ratios: [O/Fe]=3.2 and [O/Fe]=3.12 in CS22949-037 and CS29498-043, respectively. Assuming for CS22949-037 our stellar parameters and the equivalent width measurement by Depagne et al. (2002) for the forbidden line, we find [O/Fe]=2. This large difference cannot be explained by the NLTE abundance correction for the triplet and/or by a noise/telluric correction for the forbidden line. In fact, one needs forbidden line with EW$\sim$50 mÅ to provide [O/Fe]=3.2 which is clearly ruled out by observations. While the forbidden line was not measured in CS29498-043, our computations for this line predict [O/Fe]=1.1 if the triplet provides [O/Fe]=3.12.

1.4 Conclusions

Our analysis suggests that the gravities of metal-poor giants derived from the LTE Fe analysis are underestimated because of the neglect of NLTE effects. Oxygen abundance in CS22949-037 derived from the triplet and the forbidden line differ by at least 1 dex. This

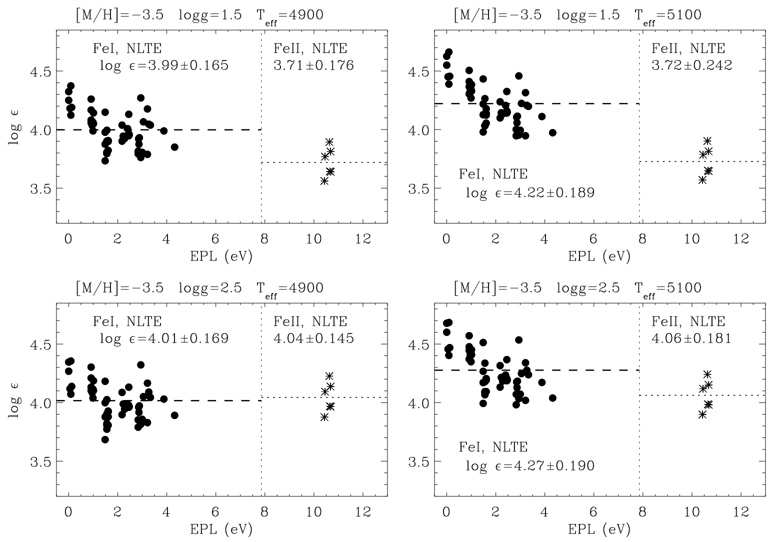

Fig. 1.2. Results of non-LTE Fe abundance determination for Fe I and Fe II lines in CS22949-037 for a small grid of model atmospheres.

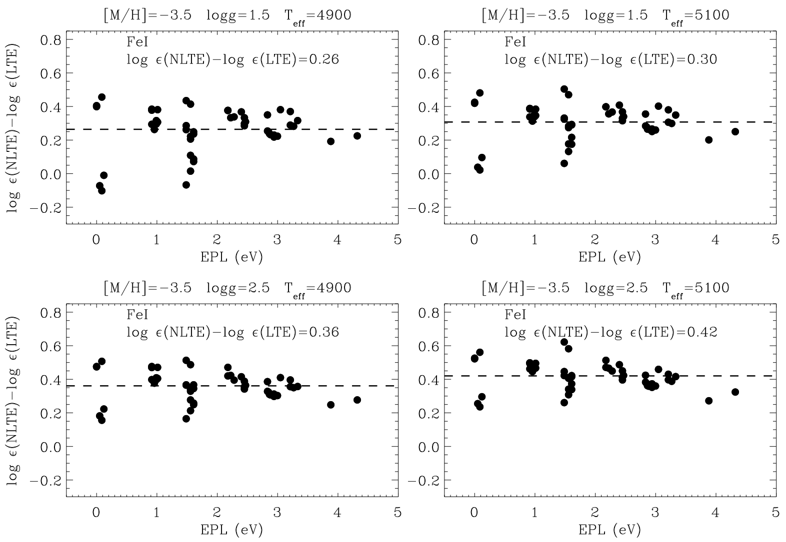

Fig. 1.3. Difference between non-LTE and LTE abundances as a function of EPL.

difference cannot be explained by NLTE effects and/or uncertainties in stellar parameters and other mechanisms must be invoked in order to explain this puzzle. However, the most possible reason of this conflict is that Kurucz (1992) models are not reliable for ultra-metal-poor giants.

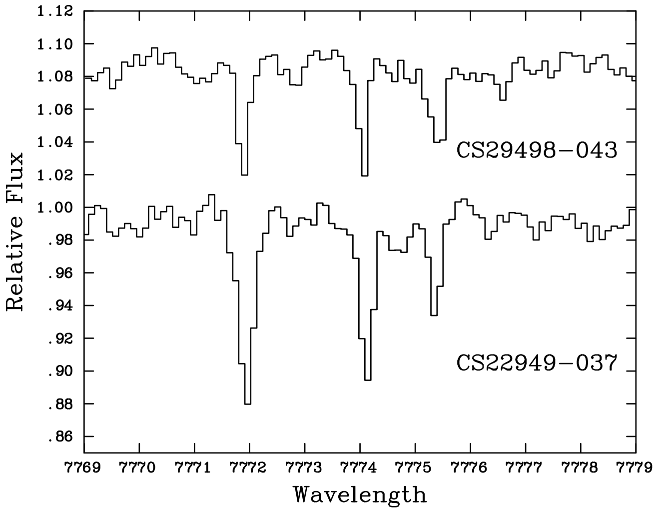

Fig. 1.4. Oxygen triplet in CS22949-037 and CS29498-043.

1.5 Acknowledgements

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