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Chemical Composition of Solar-Type Stars

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1. Introduction

The quality of the observations of the binary system α Centauri makes it an excellent candidate for stellar calibrations. The masses, the luminosities and the effective temperatures of both components are known more accurately than for most other stars. Nevertheless, the metallicity of the system, Z, is still controversial since observations lead to $0.2 \leq [Z/X] \leq 0.3$.

First, we calibrated the system with the classical MLT to treat the convection in the envelope of the two stars. This treatment needs a convection parameter (Böhm-Vitense, 1958). If we don't impose the same parameter in both stars, solutions are found for any Z and cover the whole observational $[Z/X]$ domain.

We also calibrated the system using the convection treatment of Canuto & Mazzitelli (1991). In this frame, only two parameters remain: the helium content and the age of the system, which must be adjusted to four observations, the two luminosities and the two effective temperatures. Possible solutions are found for $0.024 \leq Z \leq 0.040$.

The comparison of the calibrated values of $[Z/X]$ with the observations leads to the same constraints on Z whatever the adopted convection treatment: $0.026 \leq Z \leq 0.033$ (Fernandes & Neuforge, 1995).

A tighter constrain on the metallicity of the system should thus be provided by spectroscopy rather than by model calculations.

2. Observations, spectroscopic analysis and results

Observations were made with the 1.4 m Coudé Auxiliary Telescope (CAT) at the European Southern Observatory (La Silla, Chile). We used the Coudé Echelle Spectrometer (CES) and the long camera together with a CCD detector. Our spectroscopic analysis is differential to the Sun. Thus, spectra of α Cen A and B and the Sun were collected during two runs, in May 1993. Two exposures of each star were taken so that the final S/N ratio reaches $\sim$ 550. The data reduction were carried out with MIDAS.

For α Cen A and B, we adopted the $T(\tau)$ law of the Holveger-Müller model and we scaled it by a factor of $\frac{T_{eff\,star}}{T_{eff\,\odot}}$. For each line, the abundance is adjusted

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so that the calculated equivalent width is equal to the observed one. In each star, the microturbulence velocity, the effective temperature and the gravity are respectively determined so that the derived abundances of FeI lines are independent of their equivalent width, the derived abundances of FeI and NiI lines are independent of their excitation potentials and FeI and $FeII$ lines lead to the same abundance.

The fundamental parameters of the final model of α Cen A are: T_{eff} = 5790 ± 23 K, $logg = 4.21 \pm 0.09$, $[Fe/H] = 0.22$, $\xi_t = 1.50 \pm 0.06$ km/s.
With this model, we have obtained the following abundances: $[Fe/H] = 0.22 \pm 0.02$, $[Ni/H] = 0.25 \pm 0.03$.
These values are in excellent agreement with those of Chmielewsky et al. (1992) but our microturbulence value is higher: 1.5 km/s instead of 1.0 km/s.
The 2.2 eV FeI lines were not taken into account to derive the parameters of our model. They lead to a lower abundance of iron than the other lines: $[Fe/H] = 0.12 \pm 0.04$.
The 5380.32 and 6587.62 Å CI lines lead to $[C/H] = 0.32$ and the forbidden 6300.31 Å OI line leads to $[O/H] = 0.25$.

If we consider $[Fe/H]$ as the metallicity indicator, we find $[Z/X] \sim 0.215$, leading to Z-values around 0.027 (for a solar Z of 0.018). On the other hand, if the overabundances of C and O are taken into account, we find $[Z/X] \sim 0.276$, leading to Z-values around 0.032.

In α Cen B, FeI lines with excitation potentials different of $2.2eV$ lead to the following fundamental parameters: $T_{eff} = 5205 \pm 40$ K, $logg = 4.52$, $[Fe/H] = 0.27$, $\xi_t = 1.20$.
This effective temperature is much lower than that derived from the wings of the H_α line (5325 ± 50K) by Chmielewsky et al. (1992). However, the derived Fe abundance is the same, which means that the temperature in the layers where lines are formed are the same in our empirical model and in the theoretical model of Chmielewsky et al. (1992). Nevertheless, the opacity in the atmosphere of α Cen B increases more sharply than in the Sun. The temperature gradient is thus higher in α Cen B, leading to a wrong effective temperature if the adopted model is homologous to that of the Sun.

3. Conclusion

This analysis is preliminary and in the next future, we plan to use the Kurucz' grid of models for both stars and to confirm the overabundance of C from the analysis of CN and C_2 lines.

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