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CALIBRATION OF THE MAIN SEQUENCE STARS : ALPHA CENTAURI

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ABSTRACT New low temperature opacities have been computed and applied together with the new OPAL opacities to recalibrate the α Centauri system. Our solution is in favour of a Z value of about twice $Z_{\odot}$.

INTRODUCTION

The proximity to the Sun of the binary system α Centauri allows a good estimation of the masses of the two components, which are 1.085 $M_{\odot}$ for α Cen A and 0.900 $M_{\odot}$ for α Cen B (Demarque et al., 1986), which makes it a good candidate for main sequence calibration.

Spectroscopic analyses do not agree on the metallicity, Z. French and Powell (1971), England (1980), Edvardsson, (1988) and Cayrel de Strobel (1991) favour a Z of about twice the solar value; Furenlid and Meylan (1990) find a lower value of about 1.3 times the solar metallicity.

Previous calibrations of the α Centauri system by Demarque et al. (1986) lead to a solar Z value but other authors (Flannery and Ayres, 1978; Noels et al., 1991) found an agreement with the high Z spectroscopic results.

In this work, the calibration procedure of α Centauri is a generalization of the solar one as in Noels et al. (1991). Four observables (the two luminosities and effective temperatures of α Cen A and B) allow the determination of four unknowns : helium content, Y, metallicity, age, t, and convection parameter, α, which is assumed to be the same in both stars. This hypothesis has been discussed in Noels et al. (1991). It requires, at least, accurate low temperature opacities computed for various values of Z, not available in the previous works.

CALIBRATION WITH NEW LOW TEMPERATURE OPACITIES

We calculated our own new low temperature opacities for different Z values ranging from 0.02 to 0.04. Details can be found in Neuforge (1992). As it is shown in figure 1, these atmospheric opacities are in good agreement with the

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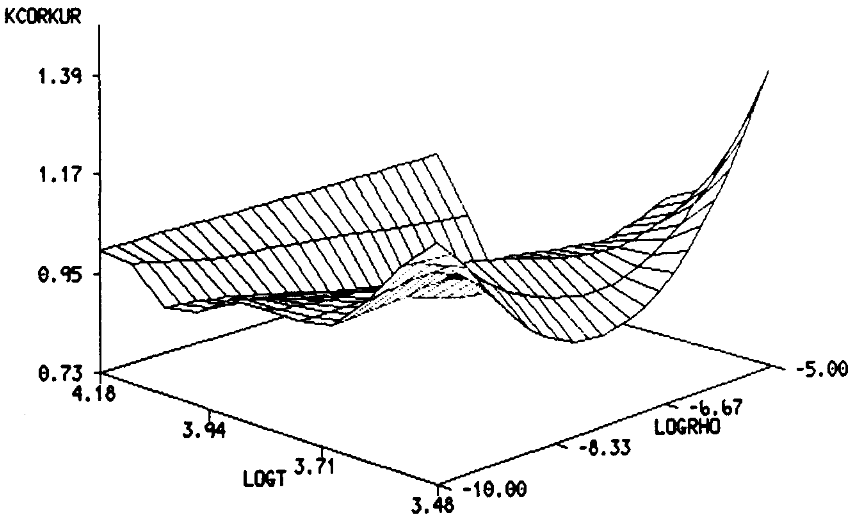

Fig. 1. Ratio between our opacities and Kurucz 's opacities as a function of lg ρ and lg T.

new atmospheric opacities of Kurucz (1992), then only available for the solar chemical composition.

With the interior opacities of Iglesias et al. (1992), OPAL, the equation of state and the nuclear reaction rates used by Noels et al. (1991), we recalibrated the Sun and found :

$$\begin{aligned} Z &= 0.02 \\ Y &= 0.281 \\ \alpha &= 2.12, \end{aligned}$$

with our own opacities while the same calibration with Kurucz 's opacities gives $Y = 0.28$ and $\alpha = 2.17$.
Our solution for the α Centauri system is

$$\begin{aligned} Z &= 0.04 \\ Y &= 0.322 \\ \alpha &= 2.25 \\ t &= 4.92 Gyr. \end{aligned}$$

DISCUSSION

The agreement found for the convection parameter in α Cen and the Sun supports our hypothesis of a unique value for the two components of α Cen. As

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in Noels et al. (1991), the uncertainties in luminosities don't affect significantly the solution; a displacement of the observational points in the HR diagram in the same horizontal direction (i.e. keeping constant the difference in effective temperature) only leads to a change in the convection parameter: a variation of the difference in Te affects the chemical composition but within reasonable uncertainties in Te's, our Z value remains large. The uncertainties in the masses, of the order of 0.01 $M_\odot$ (Demarque et al., 1986), lead to a limited change in Z. $0.035 \leq Z \leq 0.043$, while α ranges from 2.00 to 2.49.

CONCLUSIONS

The computation of new low temperature opacities for different Z values around the solar value allows us to assume a unique value of the convection parameter for the two components of the α Centauri system.

Using the OPAL interior opacities (Iglesias et al., 1992), it is possible to obtain a good fit between observational data and theoretical evolutionary tracks. In spite of the uncertainties in effective temperature, our solution is in favour of a high metallicity, $Z = 0.04$.

The new low temperature opacity tables are available on request (e-mail : U2126CN @ BLIULG11).

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