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MAIN SEQUENCE STRUCTURES INCLUDING THE OVERADIABATIC CM CONVECTION MODEL

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INTRODUCTION

We computed the main sequence structure of masses from 2 to 0.7 $M_{\odot}$ for two choices of helium (Y) and metal (Z) mass fractions. Models are given for solar composition (Y=0.285, Z=0.018) and for a composition appropriate to a younger population I (Y=0.32, Z=0.03). We took particular care both in the choice of the most recent opacities presently available and in the treatment of the input physics and numerics (see also D'Antona *et al.*, 1992).

Opacities from Rogers and Iglesias (1992) were adopted where available, complemented with those by Kurucz (1991) at T$\leq$10000 K and, elsewhere, by the Los Alamos opacities (Huebner et al. 1977). The equation of state by Mihalas et al. (1988) was used at $\rho \leq 0.01$, and elsewhere the relation P=P(ρ,T) was taken from Magni and Mazzitelli (1979), while the adiabatic gradient was obtained from a Saha type e.o.s..

As for convection, traditional models adopting the Mixing Length Theory, with $\alpha = l/H_p$=1.6, calibrated on the solar models for the composition (Y=0.285, Z=0.018) (MLT models) were compared with the results obtained adopting the new model by Canuto and Mazzitelli (CM), 1991 and 1992.

RESULTS

Extensive tables of results will be presented elsewhere (Mazzitelli and D'Antona, 1993 in preparation). The outer structure of the CM model of 1.4 $M_{\odot}$ (figure 1) is compared with an equivalent model computed in the MLT framework (figure 2). The overadiabatic gradient profile in the CM model is peaked and narrower than in the MLT, being larger in the most outer layers, but smaller in the interior. The larger gradient gives origin to a *density inversion*, which was found also in the 1$M_{\odot}$ model (CM). The density in the model of 1.4$M_{\odot}$ increases so much when going outwards that overadiabaticity drops and then rises again, close to the convective boundary, giving rise to *a double peak of the overadiabatic gradient*, as illustrated. The $T_{\rm eff}$ of this model is ~ 200K *lower* than the corresponding MLT model. The difference between the models becomes smaller as the mass decreases, and the most external layers begin to have less influence on the $T_{\rm eff}$.

The described feature produces a peculiar shape of the Main Sequence in

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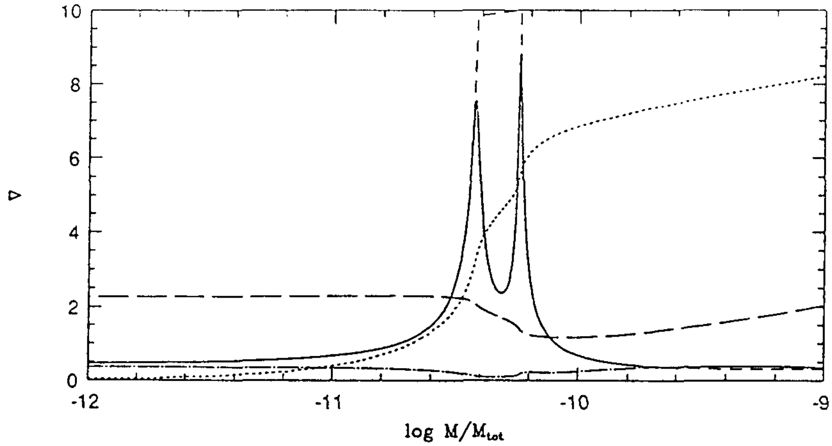

FIGURE I Structure of the external layers of a mass 1.4 $M_\odot$, having 10^8yr, in the CM framework, for $Y = 0.285$, $Z = 0.018$. The model has $\log L/L_\odot$ =0.566 and $T_{\rm eff} = 6740$K. The continuous line is the overadiabatic gradient (∇=dlog P/dlog T), short–dashed is given the radiative gradient, and dash-dotted the adiabatic gradient. The long–dashed line is $\log \rho$, which is in a scale from -8 to -3. The dotted line is the quantity (1–$T_{\rm eff}$ /T), in scale from 0 to 1.

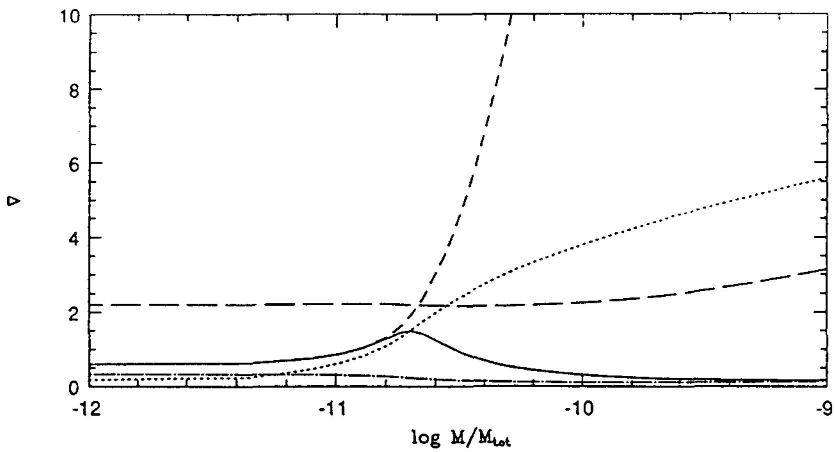

FIGURE II Structure of the external layers of a mass 1.4 $M_\odot$, having 10^8yr, in the MLT framework, with $\alpha = 1.6$. The model has $\log L/L_\odot$ =0.566 and $T_{\rm eff}$ =6910K. Lines have the same meaning as in figure 1. Convection is here more efficient than in the CM case, and consequently the overadiabatic gradient is much smaller.

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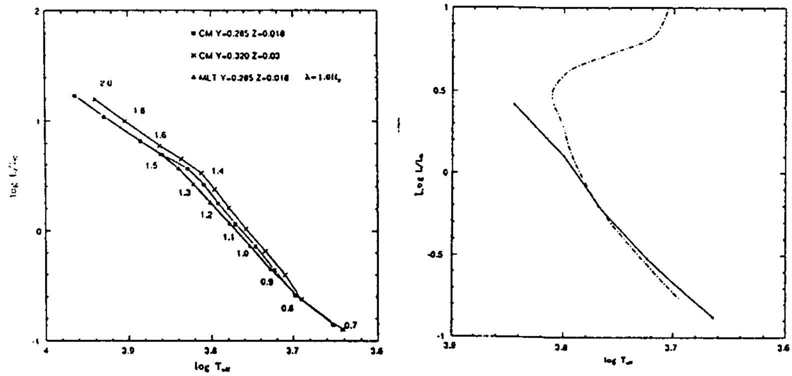

FIGURE III Left: HR diagram for the three sequences of pop. I. The models are given at an age of 10^8yr. Right: the main sequence of Z=10^{-3}, Y=0.23, age=10^8yr is shown, for masses from 1 to 0.6 $M_\odot$. A dash-dotted isochrone of age = 14×10^9yr, $Z = 2 \times 10^{-4}$ shows a small variation of slope below the turn–off, which is also due to the peculiar behaviour of CM models in this region. The opacities for the population II are from Kurucz (1991) plus Los Alamos (Huebner et al. 1977).

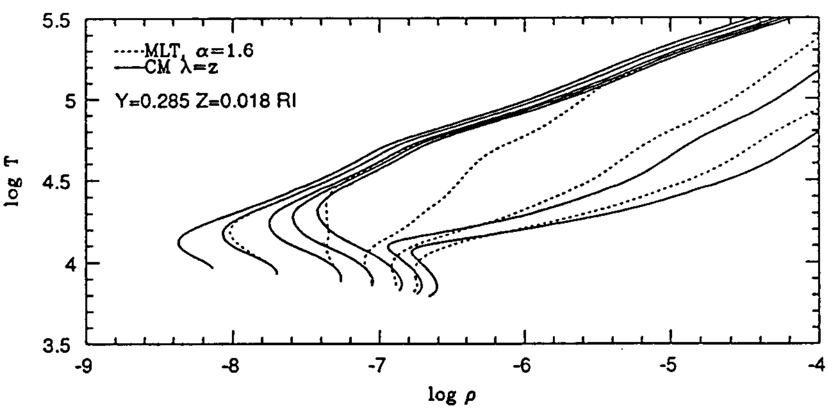

FIGURE IV Comparison of MLT tracks and CM tracks, for solar composition, in the $\log\rho, \log T$ plane. Masses are 2, 1.8, 1.6, 1.5, 1.4, 1.3 and 1.2 $M_\odot$for CM models, and 1.8, 1.6, 1.5, 1.4, 1.3 $M_\odot$for MLT models.

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the HR diagram, shown in the left part of figure 3. In fact, as long as the overadiabatic gradient is double peaked, the CM models have a steeper temperature profile than MLT models; their T_{eff} is *smaller* and the convective envelopes are correspondingly shallower. For smaller masses, when the double peak disappears, the convective extension suddenly increases (from $\sim 10^{-8}$ to $\sim 10^{-4} M_\odot$, going from 1.4 to $1.3 M_\odot$). This transition appears as *a sudden change of slope in the HR diagram.* The location of the change of slope depends on the opacities (chemical composition), as we see comparing the Z=0.018 and Z=0.03 results, and the results for $Z = 10^{-3}$ shown in the right panel of the figure. The evolutionary tracks crossing the region in which the transition occurs also present a *non monotonic* behaviour, with a peculiar shape in the HR diagram, which is exemplified by showing, dot–dashed, an isochrone at 14×10^9yr for $Y = 0.23$, $Z = 2 \times 10^{-4}$. *Whether this small feature can be observable or not in the isochrones of some open or globular cluster is to be investigated.*

The sudden onset of convection in the framework of CM convection is also seen in the ρ – T plane (figure 4) where the "gap" between the 1.4 $M_\odot$ and 1.3 $M_\odot$ models is not noticeable in the MLT framework.

POSSIBLE TESTS OF THE CM MODEL

In the models of Y=0.285, Z=0.018 the 1.4 $M_\odot$ model is located at $T_{eff} = 6740$K, in the middle of the Lithium–gap of open clusters (Boesgaard and Tripicco, 1986). The theories which are developed to explain the occurrence of the gap must be tested on CM models, and, viceversa, it is possible to use the Lithium data to constraint observationally the location, in the HR diagram, where we expect the sudden change of slope.

A careful photometry in the turn–off region of the *very metal poor* globular clusters may reveal indications of the peculiar behaviour shown in the isochrone of figure 3: this may constitute a powerful test of the atmospheric opacity computations for population II, and, eventually, even a test for the age of oldest globular clusters (D'Antona and Mazzitelli, 1993 in preparation).

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