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Lithium abundances in main-sequence F stars and sub-giants

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Abstract. The application to main-sequence stars of the rotation-induced mixing theory in the presence of μ-gradients leads to partial mixing in the lithium destruction region, not visible in the atmosphere. The induced lithium depletion becomes visible in the sub-giant phase as soon as the convective zone deepens enough. This may explain why the observed " lithium dilution " is smoother and the final dilution factor larger than obtained in standard models, while the lithium abundance variations are very small on the main sequence.

The observations of lithium in main-sequence stars on the hot side of the "Boesgaard dip" show a very small dispersion for normal stars while a light depletion (by a factor 3) is observed in Am stars (Burckhart and Coupry 2000). On the other hand, on the sub-giant branch, these stars present a lithium depletion larger than that predicted by the standard model (do Nascimento et al. 1999). These observations suggest that, while on the main sequence, the stars suffer in their internal layers a lithium destruction larger than the standard one : this extra-destruction, which must not appear at the surface in the main-sequence phase, is then dredged up during the subsequent evolution on the sub-giant branch (Vauclair 1991)

It has been suggested several times that the process responsible for this extra-depletion could be the result of rotation-induced mixing. Computations including such macroscopic motions as described by Zahn 1992 and Maeder & Zahn 1998 have recently been performed by Charbonnel and Talon 1999 and 2000. They show that the observations on the sub-giant branch can nicely be reproduced by such rotation-induced mixing. In their computationsi however, the effect of the microscopic diffusion of lithium was not introduced on the main-sequence, for the reason that in these stars the radiative acceleration may balance the lithium gravitational settling. For helium, on the contrary, the radiative acceleration is negligible : helium settling was then introduced but not taken into account while computing the meridional circulation velocity.

As shown by Mestel 1953, Maeder and Zahn 1998, Vauclair 1999, (see also Vauclair 2000 and Théado and Vauclair 2000), in the presence of vertical μ-gradients, the circulation velocity is the sum of two terms which leed to motions in the opposite direction, one which does not depend on μ (the so-called "Ω currents") and one which gathers the μ dependent terms (the "μ currents"). In case of helium gravitational settling, a "μ gradient" builts up which soon counteracts the standard meridional circulation and an equilibrium situation

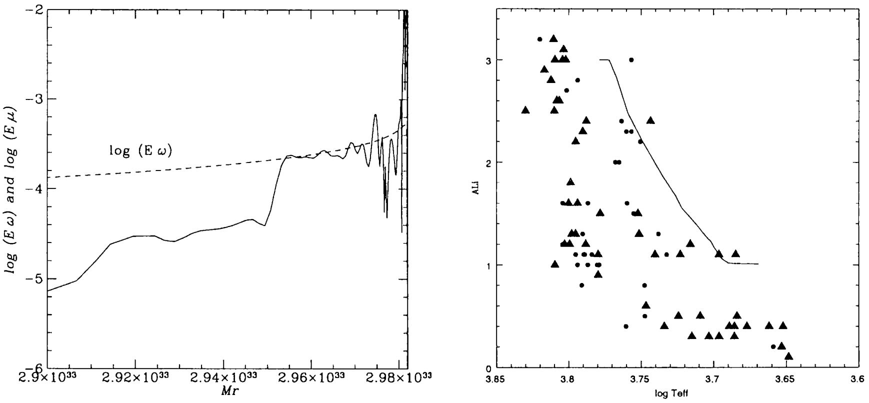

Figure 1. computations of the Ω-currents and μ-currents in a $1.5 M_{\odot}$ star with a rotation velocity of 40 km.s-1 and lithium evolution on the sub-giant branch obtained in this case, compared to the observations

may be reached, which could account for the fact that lithium is preserved on the main sequence, while extra-mixing occurs below the "frozen layer".

In the present paper, we have computed the evolution of a $1.5 M_{\odot}$ star taking into account the same effects as discussed in Théado and Vauclair 2000. We show that, when the opposite currents are taken into account, the layer just below the convection zone freezes out while mixing proceeds below. While evolving out of the main-sequence, dilution induced by the deepening of the convective zone leeds to a larger depletion than predicted by the standard model, reproducing the upper envelope of the observations. More computations are underway to extend these results to other masses and rotation parameters.

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