MASS LOSS AND LITHIUM ABUNDANCES IN POPII STARS: A NEW APPROACH OF THE PRIMORDIAL VALUE

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The observations by Spite & Spite (1982), that the upper values of the lithium abundance in halo stars are one order of magnitude smaller than the ones observed in galactic stars, lead to a large debate about the primordial lithium abundance. The whole problem can be summarized by the following question: has lithium been depleted in the outer layers of halo stars, or has the original lithium been preserved at their surfaces since the beginning?

It seems difficult to maintain the original lithium abundance in halo stars during all their lifetime. Either lithium is depleted due to element separation, or it is destroyed by nuclear reactions. Computations by Proffitt & Michaud (1989) showed that nowhere inside halo stars the lithium abundance could have remained at its original value.

It was suggested by Vauclair (1988) that rotation-induced turbulence could lead to a nuclear destruction of lithium in halo stars large enough to explain their present abundances, with an original abundance equal to the present galactic one. It seemed possible that the "plateau shape" of the abundances be preserved if the turbulent diffusion coefficient decreased rapidly with radius, as in Zahn (1987) (see also Pinsonneault et al. 1992).

Recent computations with all parameters identical to those tested for the Sun and for galactic clusters (Gaigé 1994, Charbonnel et al. 1992, Charbonnel et al. 1994) show however that rotation-induced turbulence leads to a negative slope in the "plateau", which is not observed. On the other hand, if no macroscopic motion is introduced below the convection zone, the theoretical lithium plateau also bends down for the hottest stars due to microscopic diffusion (Vauclair & Charbonnel 1994).

We suggest that the lithium dilemma for halo stars may be solved by taking into account a small mass loss, of the order of the solar wind. A small wind may slow down the element separation without levitating up to the convection zone the layers where lithium has been largely destroyed.

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The influence of stellar mass loss to counteract the effect of gravitational diffusion was first introduced by Vauclair (1975) explaining the existence of helium-rich main sequence stars. If a star is subject to a small wind, the internal changes in the star are negligible except that the matter in the outer layers is slowly replaced by other matter coming from underneath, to satisfy mass conservation. This slow motion can prevent element gravitational settling below the convection zone in cool stars.

The influence of a small wind on the abundance gradients inside the stars has been added to the diffusion computations done in Toulouse with the Geneva stellar evolution code as described in Charbonnel et al. 1992. The minimum mass loss rate needed to prevent microscopic diffusion below the convection zone in halo stars is of order 10^{-13} $M_{\odot}yr^{-1}$ for stars with effective temperatures larger than 6250K. For cooler stars microscopic diffusion is negligible.

The mass loss rate which can bring up to the convection zone, during the star's lifetime, the layers in which lithium has been largely destroyed by nuclear reactions, has also been computed. The values range from 7.10^{-12} $M_{\odot}yr^{-1}$ for the hottest stars down to 10^{-12} $M_{\odot}yr^{-1}$ for the coolest ones. This represents the maximum mass loss rate allowed for lithium to be preserved in the outer convection zone. This value decreases for cooler stars, so that we may expect a small lithium depletion increasing in stars with decreasing effective temperature, reproducing the positive slope observed for the "Spite plateau" (Thorburn 1994, Vauclair and Charbonnel 1994). In this frame, the few stars with no observed lithium should be those which suffer larger mass loss rates.

These results suggest that the initial lithium abundance in halo stars (primordial value) is given by the largest abundance observed in the hottest stars of the "plateau". **The primordial lithium abundance should be derived from the upper envelope of the observations and not from their average value :** Log N(Li) = 2.5±0.1 dex

References

Charbonnel C., Vauclair, S., Zahn, J.P. (1992): A&A 255, 191
Charbonnel C., Vauclair, S., Maeder, A., Meynet, G., Schaller, G., (1994): A&A 283, 155
Gaigé, Y. (1994): PhD Thesis
Pinsonneault, M.H., Deliyannis, C.P., Demarque P., (1992): ApJS 78,181
Proffitt, C.R., Michaud, G., (1989): ApJ 346, 976
Spite, F., Spite, M., (1982): A&A 115, 357
Thorburn, J.A., (1994): ApJ 421, 318
Vauclair, S., (1975): A&A 45, 233
Vauclair, S., (1988): ApJ 335, 971
Vauclair, S., Charbonnel, C. (1994): A&A, in press
Zahn, J.P., (1987): in Summer school in Astrophysical Fluid Dynamics (Les Houches, Elsevier Sci. Publ.)