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^{7}Li in young open clusters and binary systems

E. Tognelli[1], S. Degl'Innocenti[1,2], and P. G. Prada Moroni[1,2]

[1] Physics Department "E.Fermi", University of Pisa, Largo Bruno Pontecorvo 3, 56127, Pisa, Italy; e-mail: tognelli@df.unipi.it
[2] INFN, Largo Bruno Pontecorvo 3, 56127, Pisa, Italy

Abstract. The disagreement between observations and theoretical predictions for surface ^{7}Li abundances is still a challenging issue for stellar modellers. We re-examine the level of disagreement in the case of five young open clusters, namely Ic2602, α Per, Pleiades, Blanco 1, and Ngc 2516, and few double-lined eclipsing binaries. The calculations have been performed with our up-to-date standard evolutionary code, paying particular attention to the uncertainty evaluation on surface ^{7}Li. We found that to reproduce the observed Li($T_{\rm eff}$) profile, a convection efficiency much lower than the one needed to fit MS stars colour of each cluster is required. Such value of the mixing length parameter results to be independent of the age and of the chemical composition of the cluster.

Key words. stars: abundances - stars: pre-main sequence - stars: interiors - stars: low-mass

1. Introduction

Lithium belongs to the class of light elements, which are destroyed inside the stars at relatively low temperature (2.5×10^{6} K); such temperatures are typical not only of the inner regions of early pre-main sequence stars (pre-MS) but also of the base of the convective envelopes when such stars evolves towards the ZAMS. This makes lithium a good tracer of the mixing processes active in the stars, and from its surface abundance it is possible to infer precious constraints on the structure of convective envelopes (i.e convection efficiency). To this regard, one of the crucial point in stellar modelling is the treatment of the over adiabatic convection in stellar envelopes; the Mixing Length Theory (Böhm-Vitense, 1958) is generally adopted. However, this method relies on the choice of a free parameter α, which can depend on the star properties (Ferraro et al., 2006; Trampedach, 2007). In this brief discussion, we present some results about the comparison between theoretical predictions computed with the FRANEC evolutionary code (see e.g Tognelli et al., 2011; Dell'Omodarme et al., 2012), and observations for surface ^{7}Li abundances (see Tognelli et al., 2012, for more details).

2. Discussion

The analysis has been performed on five young open clusters: Ic 2602, α Per, Pleiades, Blanco 1, and Ngc 2516.We selected young clusters from the lithium data sample made available by Sestito & Randich (2005) in order to safely assure that lithium depletion occurs mainly during the pre-MS evolution and not during the MS. We first performed a detailed investigation of theoretical uncertainties affecting the models, which comes essentially from: 1) the chemical composition and 2) the physical inputs adopted for the computations. Regarding the chemical composition, the models have been computed adopting a suitable helium (Y) and metals (Z) abundance for each cluster; recent [Fe/H] values have been used to this purpose. The uncertainty on [Fe/H] and on the parameters adopted to convert [Fe/H] into (Y, Z), which are the helium-to-metals enrichment ratio (Casagrande et al., 2007; Gennaro et al., 2010) and the solar mixture, directly propagates into a final uncertainty on the helium and metals abundances, thus on Li depletion. Moreover, lithium destruction is strongly sensitive to the micro-physics adopted for the computations (EOS, radiative opacity and lithium burning cross section). All these uncertainty have been evaluated for each mass and chemical compositions; then, they have been quadratically added to obtain the error bars to be applied to the models (see Tognelli et al., 2012).

The age and the most suitable value of the mixing length parameter for MS stars have been fixed by fitting the color-magnitude diagrams (CMDs). Given the high sensitivity of surface ^{7}Li depletion to the adopted pre-MS mixing length parameter, we computed pre-MS models for several value of α, namely form $\alpha = 1.0$ to $\alpha = 1.9$ (a value similar to the MS one). We found that a good agreement with surface ^{7}Li data can be achieved only if a low-convection efficiency ($\alpha = 1.0$) is adopted during the pre-MS phase, independently of the star mass and cluster age and chemical composition. This value has to be compared to α =1.68 - 1.9 needed to fit the colour of the MS stars in the selected clusters CMDs. Notice that similar pre-MS convection efficiencies have been invoked in several papers to reproduce the radius of pre-MS binaries (Gennaro et al., 2012). For a few eclipsing binaries also ^{7}Li abundances have been measured, although with large uncertainties. Thus, we compared our low-convection efficiency models with such stars, finding (unfortunately) that due to the large uncertainties on ^{7}Li data a conclusive analysis is not possible, although low-convection models are not ruled out.

3. Conclusions

We re-examine the disagreement between the predicted and observed surface ^{7}Li abundance in 5 young open clusters and few binary systems, performing a detailed uncertainty analysis on ^{7}Li predictions. We computed pre-MS models with different pre-MS convection efficiency once the MS mixing length parameter has been fixed by fitting the clusters color-magnitude diagram. We found that only low-convection efficiency models are in good agreement with data, whereas models with the MS mixing length parameter value do not.

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