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Lithium abundance as a boundary condition for age and mass determination of solar twin stars

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Abstract. We explore the non-standard mixing history of five solar twins to determine as precisely as possible their mass and age. For this, we computed a grid of evolutionary models with non-standard mixing at given metallicities with the Toulouse-Geneva code for a range of stellar masses. We choose the evolutionary model that best fit the low lithium abundances observed in the solar twins. Our best model for each solar twin provides a mass and age solution constrained by their Li content and T_{eff} determination. Li depletion due to the additional mixing in solar-twins is strongly mass dependent. An accurate lithium abundance measurement connected with non-standard models provides a more precise information about the age and mass better than that determined only by classical methods.

Keywords. stars: abundances, (stars:) Hertzsprung-Russell diagram, turbulence

1. Solar twins sample

Our sample contains 5 solar twins from two sources : HIP 55459, HIP 79672, and HIP 100963, analyzed by Takeda *et al.* (2007), and HIP 55459, HIP 79672, HIP 56948, and HIP 73815 studied by Meléndez & Ramírez (2007). Effective temperatures and lithium abundances are from the respective sources. The typical errors are respectively ± 50 K and ± 36 K for T_{eff}, and 0.1 dex for log N(Li). Stellar luminosities was computed by the standard model with the help of the Hipparcos Parallaxes (van Leeuwen 2007).

2. Evolutionary Models

Stellar evolution calculations were computed with the Toulouse-Geneva stellar Evolution Code TGEC. Details of the physics can be found in Richard *et al.* (1996, 2004), Hui-Bon-Hoa (2008), and do Nascimento *et al.* (2009). Rotation-induced mixing is computed as described in Théado & Vauclair (2003). The calibration method of the models is based on the Richard *et al.* (1996) prescription, with the solar values of Richard *et al.* (2004). We obtained for our best-fit solar model $L = 3.8499 \times 10^{33}$ erg.s^{-1}, $R = 6.95938 \times 10^{10}$ cm, and log N(Li) = 1.13 at an age = 4.576 Gyrs. The sound velocity profile of our best-fit model is consistent with that deduced from helioseismology inversions by Basu *et al.* (1997). The input parameters for the other masses are the same as for the 1.00 $M_\odot$ model.

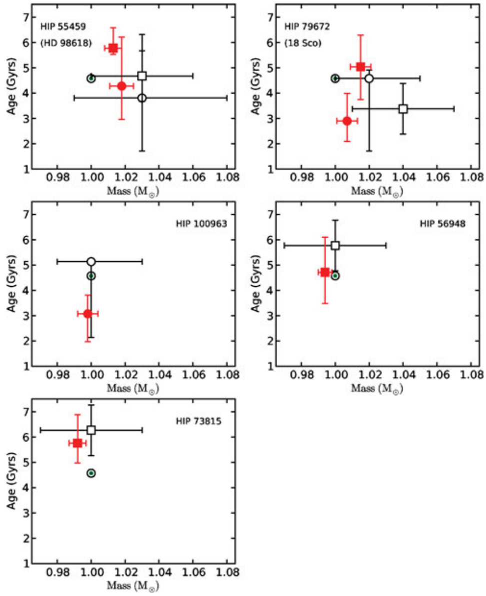

Figure 1. Comparison between masses and ages determined by TGEC models (filled symbols) and masses and ages estimated by the observations (open symbols). Squares correspond to the solar twins observed by Meléndez & Ramírez (2007) and circles to the solar twins observed by Takeda *et al.* (2007). The errors bars are as described in the text.

3. First Issues

For each star, we found the mass of the model passing through the observed point in a HR diagram. The masses inferred are within the range expected for the mass of a solar twin (± 5% of the solar mass). The precision of the mass determination is directly linked to the precision of the T_{eff} estimations from the observations. In a log N(Li)-T_{eff} diagram, the track passing through the observed point provides the most probable modeling of the observed star, and the values of our mass and age estimations. The mass determined with this method are consistent with precedent results with a better precision (see Figure 1).

An accurate Li abundance measurement and non-standard models provide more precise informations about the age and mass of solar twins, more precisely than determined by classical methods, and then a more realistic characterization of solar twin stars.

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