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The updated Pisa evolutionary model database

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

[1] Dipartimento di Fisica "E.Fermi", Università di Pisa, Largo B. Pontecorvo 3, 56127 Pisa, Italy
[2] INFN, Sezione di Pisa, Largo Pontecorvo 3, 56127, Pisa, Italy
e-mail: scilla@df.unipi.it

Abstract. We present the updated Pisa evolutionary database (available at the link: http://astro.df.unipi.it/stellar-models) which includes tracks and isochrones for evolutionary phases from the Pre-Main Sequence to the Asympthotic Giant Branch. Models are calculated by adopting a well-tested evolutionary code (FRANEC) implemented with updated physical and chemical inputs. Calculations for all the evolutionary phases have been computed for a grid of 216 chemical compositions with the fractional metal abundance in mass, Z, ranging from 0.0001 to 0.01, and the original helium content, Y, from 0.25 to 0.42 while PMS models includes metallicities up to Z=0.03. Models were computed for both solar-scaled and α-enhanced abundances with different external convection efficiencies.

Key words. Stars: evolution – Stars: pre-main sequence– Stars: horizontal-branch – Stars: interiors – Stars: low-mass – Hertzsprung-Russell and C-M diagrams

1. Introduction

Recent years showed an impressive improvement in photometric and spectroscopic observations in our Galaxy and beyond. The theoretical interpretation of these new observational results requires the availability of large database of models with a fine grid of chemical compositions, masses and ages.

2. The models

Present stellar models are computed by means of an updated version of the FRANEC stellar evolutionary code (see e.g. Tognelli et al., 2011; Dell'Omodarme et al., 2012). High temperature OPAL opacity tables are from Rogers et al. (1996)[1], in the version released in 2006, while for temperature lower than 10^4 K the code adopts molecular opacities by Ferguson et al. (2005)[2], both computed assuming the solar mixture given by Asplund et al. (2005, 2009). The adopted EOS is the most updated version of the OPAL equation of state, EOS 2006,[3] (Rogers & Nayfonov, 2002). Boundary conditions are obtained from detailed atmosphere models Castelli & Kurucz (2003); Brott & Hauschildt (2005). Nuclear reaction rates are taken from the NACRE compilation (Angulo et al., 1999) except for $^{12}C(\alpha,\gamma)^{16}O$ and $^{14}N(p,\gamma)^{15}O$, for which we adopted the recent estimates by Hammer et al.

[1] http://opalopacity.llnl.gov/
[2] http://webs.wichita.edu/physics/opacity/
[3] Tables available at: http://opalopacity.llnl.gov/EOS_2005/

(2005) and Imbriani et al. (2005), respectively. Microscopic diffusion is included in our calculations.

3. The database grid

Regarding low mass stars, tracks have been computed in the range of initial masses 0.30÷1.10 $M_\odot$ for a grid of 216 chemical compositions with the fractional metal abundance in mass, Z, ranging from 0.0001 to 0.01, and the original helium content, Y, from 0.25 to 0.42. Models were computed up to the Asympthotic Giant Branch (AGB) phase for both solar-scaled and α-enhanced abundances ([α/Fe]= 0.3) with different external convection efficiencies (with mixing lenght parameters α_{ml} = 1.7, 1.8, 1.9) for a total of 32646 tracks. Correspondingly, 9720 isochrones were computed in the age range 8÷15 Gyr, in time steps of 0.5 Gyr.

The database of PMS evolutionary tracks (mass range: M = 0.2÷7 $M_\odot$) and isochrones (age range: 1÷100 Myr), includes 20 values of metallicities (from Z = 0.0002 to 0.03), 3 values of the initial helium abundance for each Z, 3 values of the mixing-length parameter (α_{ml} = 1.2, 1.68, corresponding to the solar value and α_{ml} = 1.9) and 2 values of the initial deuterium abundance ($X_D = 4.0 \cdot 10^{-5}$ and $X_D = 2.0 \cdot 10^{-5}$) for each chemical composition, for a total of 11653 PMS evolutionary tracks and 9756 isochrones.

All the calculations are available to the astrophysical community at the link: `http://astro.df.unipi.it/stellar-models/`.

Present models are shown to be in good agreement with recent photometric data (Dell'Omodarme et al., 2012; Tognelli et al., 2011, 2012).

For old clusters, theoretical predictions about the dependence of relevant evolutionary quantities, namely turn-off and horizontal branch luminosities, on the chemical composition and convection efficiency were analyzed in a quantitative statistical way and analytical formulations are available (see Dell'Omodarme et al., 2012).

To improve the reliability of the comparisons between theory and observations a quantitative analysis of the main uncertainties still affecting theoretical predictions is needed; an extended analysis can be found in Tognelli et al. (2011), Valle et al. (2013), Tognelli et al. (2012).

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