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WEBCESAM: a web interface for stellar evolution calculations

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Abstract. WEBCESAM offers the possibility of very simple access to stellar evolution calculations. The web page `http://astro.ensc-rennes.fr/webcesam` allows the user to set the values of mass, mixing length, overshooting amount and chemical composition (Y, Z). Computations are made on the server, after their end, the user can download output data files from an "on-the-fly" generated web page.

Key words. Stars: abundances – Stars: atmospheres – Stars: Population II – Galaxy: globular clusters – Galaxy: abundances – Cosmology: observations

1. Introduction

Computation of stellar evolutionary tracks is an heavy task in terms of code development, CPU time and files management. Most of the software aimed at stellar evolution calculations are not very easy to use. Hence a simple interface could make stellar evolutions accessible to non-expert users (researchers or advanced students) and could improve the productivity in the case of massive calculations (as a grid computation). A web based solution allows a high level of ubiquity and makes code updating easier for developers. With WEBCESAM, anybody can run the well known stellar evolution code CESAM (see Morel 1997 and Morel & Lebreton 2007) through any Internet browser.

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2. WEBCESAM

2.1. Code, Numerical Method, Physical Assumptions and system limitations

CESAM is a 1-D stellar evolution code, originally written by Pierre Morel at the Nice Observatory. Several developments have been made by many authors. The official current version is available on the Nice Observatory web site, my version can be downloaded from my server. Depending on its version, the CESAM source code contains around 30,000 lines. On the numerical side, the solution of the quasi-static equilibrium is projected on a B-splines basis and the Henyey's method is applied. In each stellar model, the mesh is not uniform and its exact size is automatically adapted during the calculation (each model containing around 800 shells).
Opacity tables are from Iglesias & Rogers (1996) (OPAL96) for high temperature ($T \geq$

10000 K) and Alexander & Fergusson, (1994) for cooler domains. Magee & Clark (1995) elemental opacities (Los Alamos) have been used within He-burning regions, for more explanation see Cordier et al. (2002). Equation of state (EOS) is the OPAL one (see Rogers et al. 1996) and EFF (see Eggleton et al. 1973) for He-burning core. Nuclear reactions rates are mainly taken from the NACRE database (Angulo et al. 1999).
The convective energy flux is computed in the frame of the canonical Mixing Length Theory (MLT). The convective zones boundaries are determined thanks to the Schwarzschild's criterion. In the case of a convective core, an extra-mixing zone can be added; the length of this region being fixed by the user an expressed in pressure height unit.
The FORTRAN sources of the stellar evolution code itself can be downloaded at this URL: `http://astro.ensc-rennes.fr` (in the "*Yellow* CESAM" section); this is a code derived from the official version "CESAM 3.2".

2.2. Input parameters

WEBCESAM inputs are divided into two categories:

- physical parameters:
  - the total **initial mass** of the object (allowed range: 0.8 to 12.5 solar masses)
  - the **mixing length value** (in pressure scale height $H_{\rm P}$), well accepted values spread around 1.5 $H_{\rm P}$.
  - the **overshooting** amount added above the convective core when it occurs within the stellar structure. This quantity has to be expressed in pressure scale height. In the literature models called "standard" are generally computed without overshooting, those computed with a "mild" overshooting amount use values around 0.2 $H_{\rm P}$.
- chemical parameters:
  - Initial mass fraction of helium (Y_0)
  - Initial mass fraction of elements heavier than helium (Z_0)

2.3. Output data

After computations completion, the user receives an e-mail notification of the WEBCESAM outputs URL, where he could find an "*on-the-fly*" generated web page displaying the following files:

- The standard CESAM output file: `comp_ID.out_std` , where "`comp_ID`" is a chain of characters, given by the user in order to identify his run. This file provides along the track: age, $\log T_{\rm eff}$, $\log L/L_\odot$, $M_\star$, $\log R_\star/R_\odot$; quantities related to stellar center: $\log T_{\rm c}$, $\log P_{\rm c}$, $\log \rho_{\rm c}$, X_c anf Y_c.
- The extended CESAM output file: `comp_ID.HR` (it shows –among other things– positions of convective zones boundaries). As this file has a rather complex structure a FORTRAN program, that reads these data, is provided.

As CESAM theoretical outputs are converted into observational ones using the BaSEL stellar atmospheres library (Lejeune et al. 1998), two additional files are provided, giving photometric data: `comp_ID.tgl.UBVRI` for the Johnson UBVRI system and `comp_ID.tgl.geneva` for the Geneva one.

Computation main parameters are also recalled: mass, chemical composition (in mass fraction), mixing length and overshooting values. For immediate viewing the outputs web page contains two figures showing the evolutionary track: first in the ($\log T_{\rm eff}$, $\log L/L_\odot$) diagram, the second in the ($B-V$, M_V) one.
In the present version of WEBCESAM, computations are stopped when model has reached the red giants branch. A grid of evolutionary tracks, calculated thanks to WEBCESAM, is shown in the figure 1.

3. Perspectives

In its present state WEBCESAM provides an easy access to stellar evolution calculations with fine tuning of mass, chemical composition, mixing length and overshooting parameter, it is particularly suitable for non-expert users (students, researchers of other fields, ...)

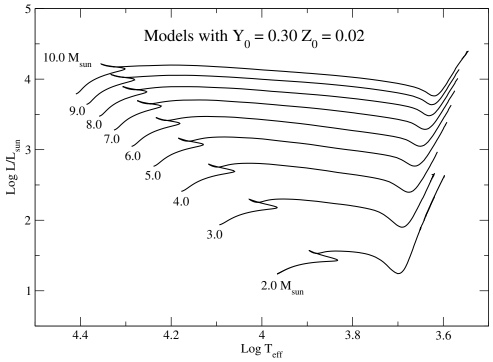

Fig. 1. An example of a grid of stellar evolution tracks computed with WEBCESAM, chemical composition is the solar one, masses spread from 2.0 to 10.0 solar masses.

If WEBCESAM meets its audience in the near future, further improvements and developments could be planned: full stellar structure providing at user chosen ages, choice between several nuclear reaction rates, EOS and opacity tables, temperature gradient formalisms (MLT or Canuto & Mazzitelli 1991), etc.
For the moment WEBCESAM runs a code version based on the official CESAM 3.2, it could be replaced by the up-to-date CESAM2k (see Morel & Lebreton 2007). WEBCESAM user IDs are granted by the author after e-mail request (`daniel.cordier@ensc-rennes.fr`) in the limit of the computer resources.

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