Seismology Working Group

Evolution and Seismic Tools Activity
Past and Present

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Objectives

ESTA aims at contributing towards the preparation and exploration of the scientific results of CoRoT. In order to achieve this, the goals set for ESTA are:

- to provide a **grid of reference stellar models and their frequencies** of oscillation,
- to extensively **test, compare and optimize numerical tools** used to calculate:
  - stellar models,
  - oscillation frequencies,
  - and seismic inversions.

Besides the development of the codes there will also be an effort towards documenting the codes and their outputs. The impact of ESTA can be consolidated if the comparisons are complemented by documentation of the tools being optimized and of the data they produce.

As part of the effort towards **documenting the codes and their outputs** the work produced for this workshop can be used as a first iteration on documenting the evolution codes. Particular attention should be given to those cases where such descriptions do not exist yet.

It is also important to establish **reference data formats** to be used for the exchange of data. It improves the efficiency of the comparisons and allows a wide exploitation of the output produced by the codes. The seismic tools available can be more easily applied to evolutionary sequences and models if all data can be made available in a few fully documented data formats. Some time should be given to discuss how this cauld be implement in a realistic (viable) and useful way.

In order to facilitate the use and exchange of data from different evolution and seismic codes **conversion and analysis tools** will be developed and made available. The type of tools that may be necessary should also be identified as the activity progresses, to be produced as required.

Participants

Belgium:
Anwesh Mazumdar
Andrea Miglio
Josefina Montalban
Arlette Noels
Richard Scuflaire
Anne Thoul

France:
Gabrielle Berthomieu
Matthieu Castro
Marie Jo Goupil
Yveline Lebreton
Pierre Morel
André Moya
Phi Nghiem
Pascal Lambert
Bernard Pichon
Janine Provost
Sylvie Vauclair

Denmark:
Michael Bazot
Joergen Christensen-Dalsgaard

Germany:
Achim Weiss

Italy:
Scilla Degl'Innocenti
Maria Pia di Mauro
Marcella Marconi
Alessandra Ruoppo

Participation is open to all colleagues from *CoRoT contributing countries* willing to contribute to the comparison either with evolution or with seismic tools. An up-to-date list of participants is maintained at the ESTA webpage and there is a distribution list for emails used to exchange news on ESTA related activities.

Portugal:
Margarida S. Cunha
João M. Fernandes
João P. Marques
Mário J.P.F.G. Monteiro
Teresa C. Teixeira

Romenia:
Marian D. Suran

Spain:
Rafael Garrido
Juan Carlos Suarez

United Kingdom:
Ian W. Roxburgh
Michael J. Thompson

Tools

Stellar Evolution Codes:

- **ASTEC** - *Aarhus Stellar Evolution Code*
  By: J. Christensen-Dalsgaard
- **CESAM** - *Code d'Evolution Stellaire Adaptatif et Modulaire*
  By: P. Morel
- **CLÉS** - *Code Ligeois d'Evolution Stellaire*
  By: R. Scuflaire and the BAG
- **FRANEC** - *Pisa Evolution Code*
  By: S. Degl'Innocenti et al.
- **GARSTEC** - *Garching Stellar Evolution Code*
  By: A. Weiss
- **STAROX** - *Roxburgh's Stellar Evolution Code*
  By: I. Roxburgh
- **TGEC** - *Toulouse-Geneva Evolution Code*
  By: S. Vauclair et al.
- ...

Stellar Oscillations Codes:

- **ADIPLS** - *Aarhus Adiabatic Pulsation Package*
  By: J. Christensen-Dalsgaard
- **FILOU** - *Meudon Oscillations Code*
  By: F. Tran Minh & L. Leon; J. C. Suarez
- **GraCo** - *Granada Oscillation Code*
  By: R. Garrido & A. Moya
- **NOC** - *Nice Oscillations Code*
  By: Y. Osaki, G. Berthomieu, J. Provost
- **POSC** - *Porto Linear Adiabatic Oscillations Code*
  By: M. Monteiro
- ...

Conversion Tools:

- **MODCONV** - *Stellar Models Conversion Tool*
  By: M. Monteiro
- ...

Reference grid - CESAM

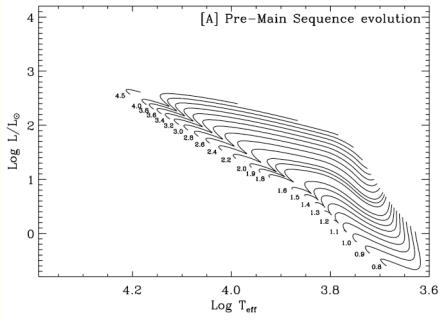
Physics:

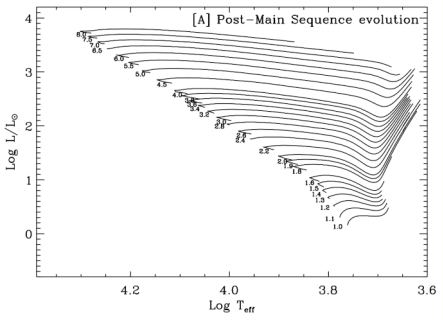
ITEM	Selection	References
EoS	OPAL	Rogers et al. (1996, 2001 Tables)
Opacities	OPAL	Iglesias & Rogers (1996) Alexander & Fergusson (1994)
Reaction rates	NACRE	Angulo et al. (1999)
Convection	MLT (α = 1.6)	Bohm-Vitense (1958) + Henyey et al. (1965)
Overshoot	*none*	-
Diffusion/settling	*none*	-
Mixture	Solar	Grevesse & Noels (1993)
Atmosphere	Grey	-

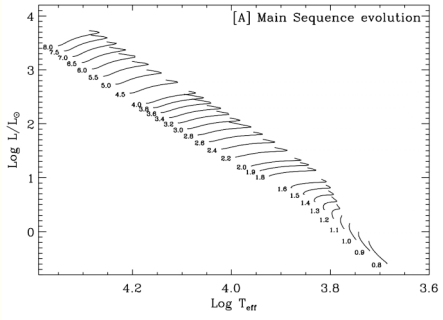
Parameters: $Y_0 = 0.28$
$Z/X_0 = 0.02857$
$M/M_\odot \in [0.8, 8.0]$

The evolutionary sequences and the models have been calculated with **CESAM (2K)** while the frequencies were determined with **POSC**, by Marques, Fernandes & Monteiro.

All data (sequences, selected models and their frequencies) are/will be available for download from the ESTA webpage. Additional models and frequencies can be provided on request.







Other grids - CLÉS

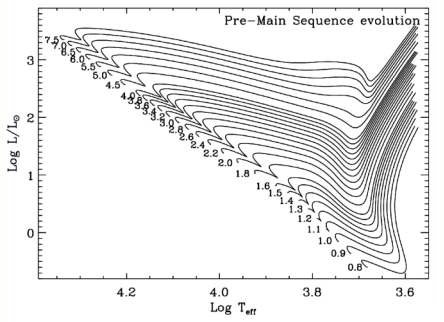
Physics:

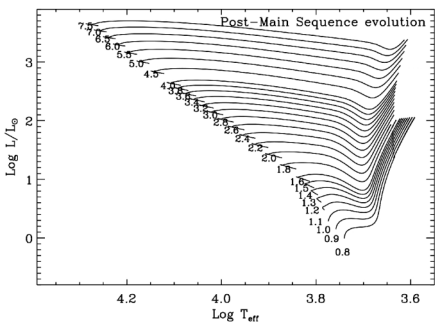
ITEM	Selection	References
EoS	OPAL	Rogers et al. (1996, 2001 Tables)
Opacities	OPAL	Iglesias & Rogers (1996) Alexander & Fergusson (1994)
Reaction rates	NACRE	Angulo et al. (1999)
Convection	MLT (α = 1.6)	Cox & Giuli (1968)
Overshoot	*none*	-
Diffusion/settling	*none*	-
Mixture	Solar	Grevesse & Noels (1993)
Atmosphere	Kurucz	-

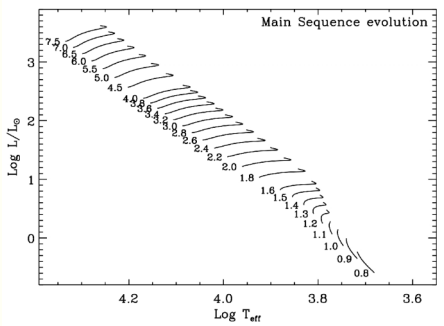
Parameters: $Y_0 = 0.28$
$Z/X_0 = 0.02857$
$M/M_\odot \in [0.8, 7.5]$

The evolutionary sequences have been calculated with **CLÉS**, by Montálban.

Data (sequences) are available for download from the ESTA webpage.







Comparisons: Models

Task 1:

Under this task a few **specific, fully identified, stellar cases** have been proposed to compare the evolution codes. The physical assumptions proposed as the reference for the comparison have been defined and stellar models at different stages of evolution have been identified in order to cover as much as possible a representative range of stellar mass and age.

The comparison is expected to address how the physics and the numerical implementation of the physics may affect the result of different codes. Discrepancies are to be used to optimize and develop the codes in order to produce consistent outputs between codes.

Both the stellar parameters of the selected models and their inner structure are compared. Clues on what are the sources of problems and what items should be further analized are the major results.

Yveline Lebreton will tell us more about this task tomorrow....

Task 2:

Global constraints on a few stellar cases are provided, in a *hare-and-hounds* type of exercise, so that the "best" models are produced by the *hounds* to reproduce the model constraints indicated by the *hare(s)*.

The goal is to established the range of possible solutions provided by different codes and selections of the physics when the same "observational" case is being modeled.

This task has been waiting for a sucessfull completion of the initial phase of Task 1.

More will be presented and discussed about this task tomorrow...

Comparisons: Frequencies

The goal is to compare the calculation of the oscillation properties of the models when different codes and sets of assumptions are used (boundary conditions, linearity, adiabaticity, rotation, magnetic fields, etc) .

Some comparisons have already been initiated using the models from the reference grid.

The comparison of the seismic codes could be the topic of a specific ESTA Workshop.

Task 3:

For this task, **particular types of stellar pulsators** are study in order to quantify the uncertainty on the predicted seismic parameters for these stars.

Models and frequencies, as calculated by different codes, will be produced in order to quantify the range of solutions found for the frequencies in each class of pulsators.

Andy Moya will tell us more about this task tomorrow...

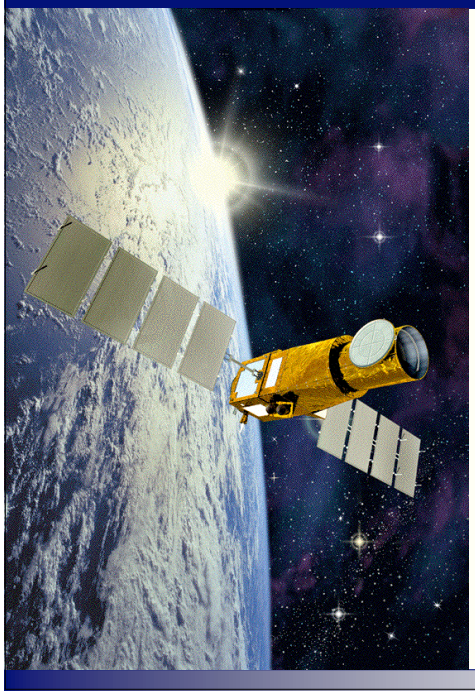
Strategy

In order to achieve the goals set for ESTA the adopted strategy up to now (to be revised if necessary!) has been:

- To make **as much information as possible available** on:
  - evolution codes,
  - seismic codes,
  - data produced by these tools.

- To **initiate coordinated activities**, aiming at inducing the development of the codes and the discussion of the physical assumptions used in these codes, by:
  - setting specific tasks,
  - facilitating the exchange of data,
  - establishing new collaborations.

- To **produce and make available reference data** useful for asteroseimology of stars across the HR diagram, namely:
  - evolution sequences,
  - stellar models,
  - oscillation frequencies.



All information is made available at:

www.astro.up.pt/corot/

If you have any suggestion, data, information, documents, etc, relevant for ESTA please contact me at:

mjm@astro.up.pt

New initiatives that can complement and/or extend the present activities are welcome!

Now lets move on to the real work...