

TOUCAN: A VO tool for asteroseismology. Scientific preparation and exploitation of the PLATO mission.

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Abstract

In the last decades space missions, ground-based networks and dedicated photometric and spectroscopic programs have caused a dramatic increase of the asteroseismic and related data. A proper understanding and full exploitation of this huge amount of information requires a similar leap forward on the theoretical side. Analysis of all space and ground-based associated data requires theoretical models developed by different groups, with different codes, numerical approximations, physical definitions, etc. This lack of homogeneity makes it difficult to design automatic tools to simultaneously work with different models and/or applications able to use the models on the fly.

Here we present TOUCAN: The VO gateway for asteroseismic models, which is a distributed tool conceived to work with VO-compliant models. In the Virtual Observatory, models are described according to the same data model and accessed using the same access protocol which solves all the issues regarding data discovery, data access and data representation present in non-VO tools. TOUCAN will play an important role in the preparation and scientific exploitation of PLATO data.

1 Introduction

Asteroseismology provides an extremely detailed picture of the internal structure and dynamics of stars thanks to the observation and analysis of their seismic properties. Space missions like SOHO[[1]], MOST [[12]], CoRoT [[2]], Kepler [[4]] and SDO [[6]] have produced a dramatic increase in the asteroseismic and related data, and other present and future projects

like Gaia [[5]] and PLATO [[8]] are expected to increase the available datasets by a factor of hundreds. What's more, ground-based networks (like GONG [[9]] and Bison [[3]]) and dedicated photometric and spectroscopic follow-up observations for the above-mentioned space missions (See, for instance, [[7]] and [[11]]) also continuously increase the amount of related data.

In order to be able to properly analyse and interpret this huge amount of observational data, we need a equivalent leap forward on the theoretical side. But simulations of complex systems produce huge amounts of information that are difficult to manipulate, analyse, extract and publish. This situation is even worse if theoretical models are developed by different groups, with different codes, numerical approximation, physical definitions, file formats, etc. This lack of homogeneity makes it difficult to design automatic tools to simultaneously work with different models and/or applications able to use the models on the fly.

TOUCAN is a distributed tool developed by the Spanish VO¹, conceived to work with VO-compliant asteroseismic models, with the aim to easily handle stellar and seismic models developed by different groups, analyse their properties and, eventually, compare them to observational data. In order to do this, all models are described according to the same data model and are accessed using the same protocol. This VO approach solves the issues regarding data discovery, data access and data representation present in non-VO tools.

The development of TOUCAN is done over its precursor VOTA² [[10]] but with a different architecture based on server/client VO services. It will consist in a central service that will manage the user queries to TOUCAN and will communicate with peripheral services and with users.

TOUCAN has recently been adopted by the SpaceInn consortium to link the asteroseismic observations with models. SpaceInn congregates a significant portion of the asteroseismology community to build on the existing European strength in the field of time-domain stellar physics. SpaceInn activities, which are organised around the themes of data access, scientific expertise and existing coordination, aim to secure optimal use of the existing and planned data, from space and from the ground, in helio- and asteroseismology.

TOUCAN is currently a tool under developement. It will be available soon at <http://svo.cab.inta-csic.es/projects/toucan>.

2 TOUCAN

2.1 A common data model

In what follows, we will name as a “data collection” the set of results (metadata and files) obtained by a research group running a simulation with the same physical inputs. Each data collection is developed and maintained by a different research group, using their own numerical code, with different algorithms, physical assumptions, etc. To allow for efficient discovery and comparison of data collections we define a data model with the most relevant

¹<http://svo.cab.inta-csic.es>

²<http://svo.cab.inta-csic.es/theory/sisms3>

properties common to all them.

First, so that users can make an informed decision on what data collections are relevant for their use case the physics and algorithms involved must be described. This can be done using keywords classified in different categories: Atmosphere, Chemicals, Convection, Diffusion, EOS, Global Parameters, Nuclear, Opacity, Rotation and Seismology (See Fig. 1).

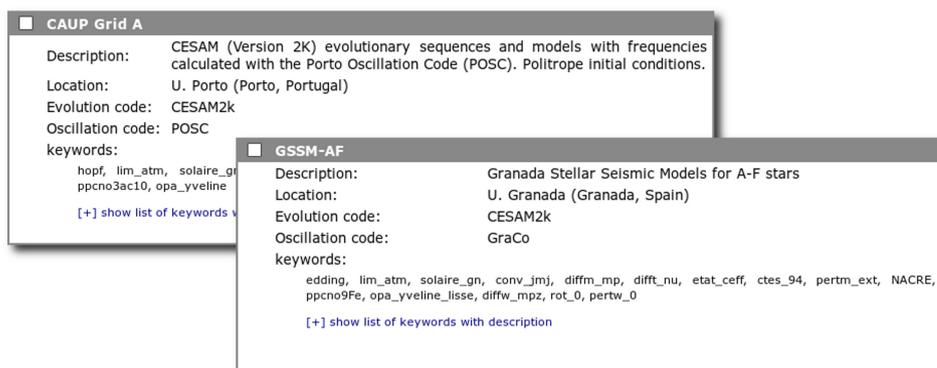


Figure 1: An example of two data collections created by different research groups, using different numerical codes for computing seismic properties and with different physical inputs.

Then, models are described using a common data model including properties related to stellar model structure, evolution and seismic behavior (See Fig. 2). This allows to make discovery queries on different models at the same time and visualize and compare the results independently of the code that was used to compute them.

2.2 Distributed architecture

TOUCAN is conceived as a distributed framework (See Fig. 3), with a TOUCAN Peripheral Service (TPS) for each data collection, located where the models are computed, and a TOUCAN Central Service (TCS) that communicates with them and serves as the main end-point to interact with the final users.

All the global properties are kept in a central database at the TCS and will be used to answer most user discovery queries. The structure and oscillation spectra files are stored in the TPS nodes and are accessed by the TCS for downloading, making different cutouts or visualization.

Whenever new models are computed in one peripheral node, central TOUCAN will harvest the global metadata corresponding to the simulation results and will add them to the central database.

Users will access the TCS web interface. They will select those collections that are of interest for their use case (See Fig. 1) and then they will be presented a form (See Fig. 4) to discover simulations of interest in terms of the global parameters. With these parameters,

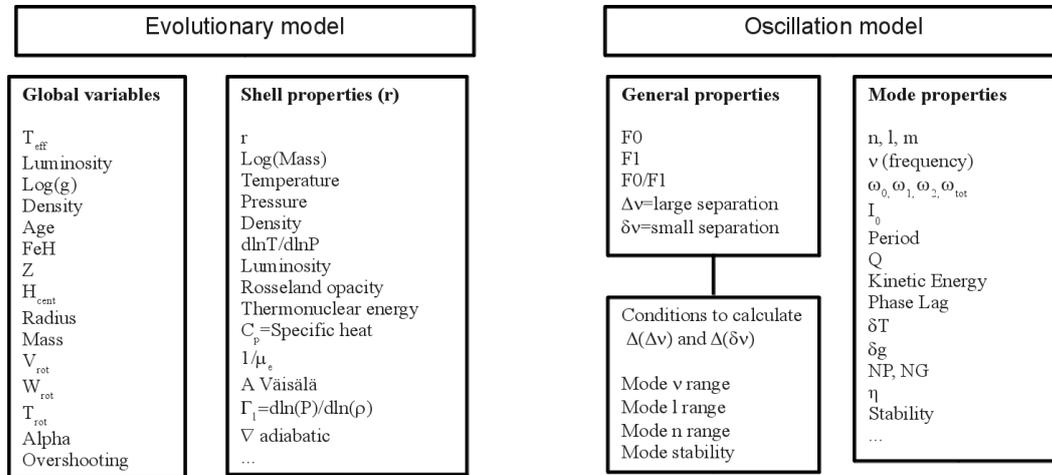


Figure 2: Models are described using a common data model.

some HR diagrams can be made, where users can plot all the results of a query visualizing one global property versus another one. Then, if the user is interested in inspecting individual results, central TOUCAN will retrieve the necessary files from the corresponding peripheral nodes and thus they will be available to full download, make cutouts or plot some file property versus another one.

In some particular cases, in order to answer complex queries (for instance, when the value of the large separation is required to be computed with a restriction in the range of frequencies) TCS will have to query the peripheral nodes using a VO protocol to find the models that match the required conditions.

Some of the peripheral services may have implemented a Grid/Cloud infrastructure to accept on-demand modeling queries and launch local scripts to run the computations. This way we aim at merging two technological paradigms in astrophysics: the Virtual Observatory as the standard framework for discovery, access, and representation of data, and the Grid environment for massive computing.

Acknowledgments

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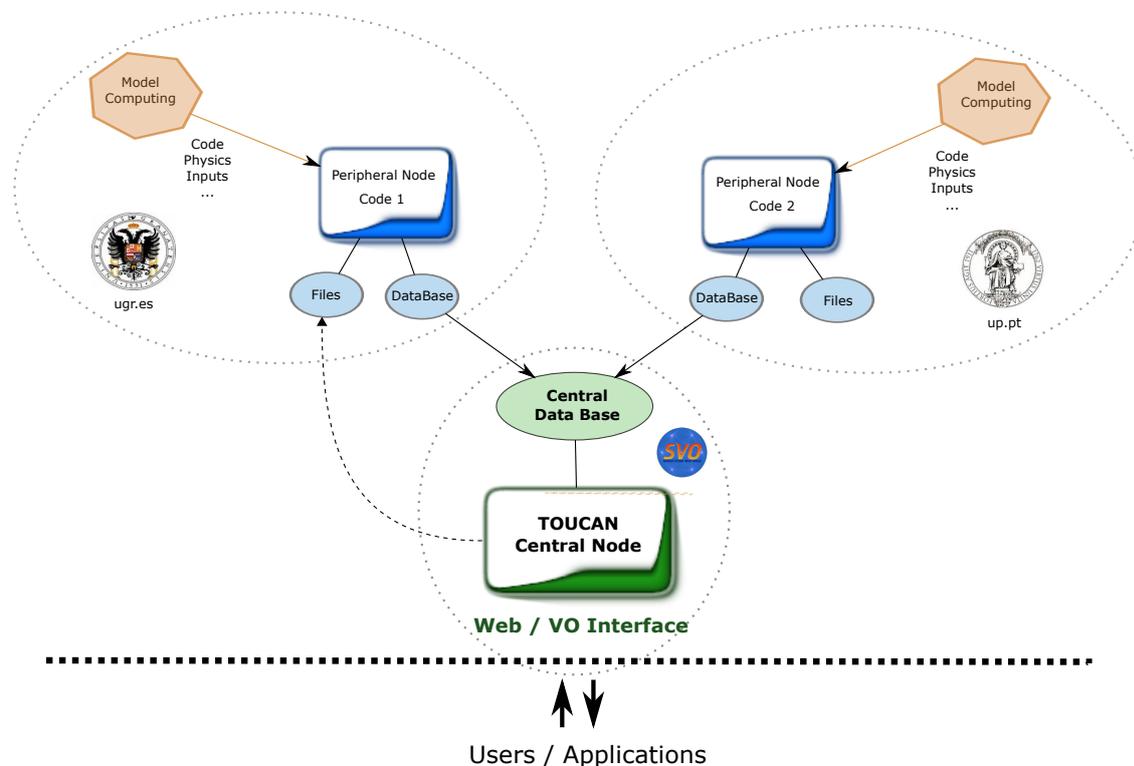


Figure 3: TOUCAN is a distributed tool. Central TOUCAN Service (TCS) is the web front end for interacting with users. It keeps a central database with the global metadata of the data collections available in the different nodes. The peripheral services keep the full information about their own simulations and the corresponding data files. Eventually, when data files are needed, TCS contacts the corresponding nodes to retrieve them so that users can download or make plots with them.

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Stellar global parameters			Seismology parameters		
(?)	T _{eff}	<input type="text"/> - <input type="text"/> (K)	(?)	F0	<input type="text"/> - <input type="text"/> (μHz)
(?)	Lum	<input type="text"/> - <input type="text"/> (L _{sun})	(?)	F1	<input type="text"/> - <input type="text"/> (μHz)
(?)	Log(g)	<input type="text"/> - <input type="text"/>	(?)	F0/F1	<input type="text"/> - <input type="text"/>
(?)	Density	<input type="text"/> - <input type="text"/> (g/cm ³)	(?)	Δν	<input type="text"/> - <input type="text"/> (μHz)
(?)	Age	<input type="text"/> - <input type="text"/> (Myr)	(?)	δ(ν)	<input type="text"/> - <input type="text"/> (μHz)
(?)	[Fe/H]	<input type="text"/> - <input type="text"/>	Seismology search options		
(?)	Z	<input type="text"/> - <input type="text"/>	(?)	ν	<input type="text"/> - <input type="text"/> (μHz)
(?)	Hcent	<input type="text"/> - <input type="text"/>	(?)	l	<input type="text"/> - <input type="text"/>
(?)	R _*	<input type="text"/> - <input type="text"/> (R _{sun})	(?)	n	<input type="text"/> - <input type="text"/>
(?)	Mass	<input type="text"/> - <input type="text"/> (M _{sun})	(?)	Sta.	<input type="text" value="all modes"/>
(?)	Vrot	<input type="text"/> - <input type="text"/> cm/s	(?)	νSta	<input type="text"/> - <input type="text"/> (μHz)
(?)	Wrot	<input type="text"/> - <input type="text"/> rad/s			
(?)	Trot	<input type="text"/> - <input type="text"/> sec			
(?)	α _{MLT}	<input type="text"/> - <input type="text"/>			
(?)	Over.	<input type="text"/> - <input type="text"/>			

Figure 4: TOUCAN allows users to make queries using the global parameters defined in the data model.

[10] Suárez, J.C. et al. 2014 A&A 563, 7

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