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Theoretical models in the Virtual Observatory

C. Rodrigo[1] and E. Solano[1]

[1] Spanish-VO. CAB (INTA-CSIC). P.O. Box 78, 28691 Villanueva de la Cañada, Madrid, Spain

Abstract

Although full interoperability between theoretical and observational data in the framework of the Virtual Observatory would be a very desirable achievement, the current status of VO offers few approaches to handle theoretical models. TSAP (Theoretical Spectra Access Protocol) has been proposed as a tool to fill this void, providing a simple scheme to easily operate with this kind of data. Another simple protocol, S3, has been proposed as a generalization of the same ideas for other types of theoretical data. As examples we show servers using S3 for isochrones and evolutionary tracks and asteroseismology models.

1 Introduction

Theoretical models are widely used in Astronomy. Synthetic spectra, for instance, can be used to infer the physical properties of an object by comparing its observed spectrum to a theoretical collection of spectra. A number of libraries of theoretical models are presently available in the Internet. They can be downloaded as a collection of data files with, in some cases, the help of a web form allowing a previous selection of the files of interest. The results are usually presented in different formats as ASCII or FITS files.

This scenario forces the user to perform a previous work in order to be able to compare theoretical and observational data. The situation is even worse if different sets of theoretical models, developed by different groups, are used. This lack of homogeneity makes it difficult to design automatic tools to simultaneously work with different models and almost impossible to develop applications able to use the models on the fly.

One of the aims of the Virtual Observatory is to guarantee a full interoperability not only between observational data but also between them and theoretical data. However, there are a number of issues that make it difficult to achieve this goal. One of them is the clear VO bias towards observational data. This can be seen, for instance, in the main protocols and standards already developed: SSAP, SIAP, ConeSearch,..., all of them require the object position or name as mandatory, parameters that are meaningless when dealing with theoretical models.

Actually, depending on the physical problem to be tackled, the particular approach taken by the author of the model or even his/her own personal preferences, the set of parameters used to characterize the model usually differs from one to another. This makes it difficult to define a general data model for theoretical data, a major topic for the IVOA[1] and Euro-VO[2] Theory Groups.

2 Theoretical spectra in the VO: TSAP

TSAP is simple protocol to access theoretical spectra. It was initially developed as a collaboration between ESA-VO[3] and SVO[4] as a way to make theoretical data easily available through the VO. It is included now as a use case for theoretical spectra in the SSAP standard protocol[5].

TSAP can be described as a dialogue between the client application and the model server based in three main steps:

- What parameters define this model? what do they mean? and what values are allowed for each of them?
- What files are available for a given range of those parameters?
- How to obtain the files?

It is in the first step where the main differences with SSAP become remarkable. SSAP requires the object position (RA and DEC) together with a search radius as mandatory parameters, something that has no meaning when working with theoretical data. With TSAP the client first asks the server about the parameters than can be used to make the query. This is made in terms of an http query with the *format=metadata* parameter. On return, the server provides a VOTable that follows the SSAP specification and that contains all the queriable parameters, their descriptions (human readable descriptions if possible) and, if desired, the allowed values or ranges of values. The client must be able to read this metadata VOTable and build a form to make the real query.

TSAP is not just an interesting idea, it is a working protocol. There are several servers of theoretical models using TSAP[6] [7] and applications able to access those services to retrieve theoretical spectra and compare them with observed data[8]. See Fig 1.

[1]http://www.ivoa.net
[2]http://www.euro-vo.org
[3]http://esavo.esa.int
[4]http://svo.cab.inta-csic.es
[5]http://www.ivoa.net/Documents/latest/SSA.html
[6]CAB theoretical model server, http://svo.cab.inta-csic.es/theory
[7]PEGASE, http://leda.univ-lyon1.fr/e31/
[8]VOSPEC, http://www.sciops.esa.int/index.php?project=ESAVO&page=vospec

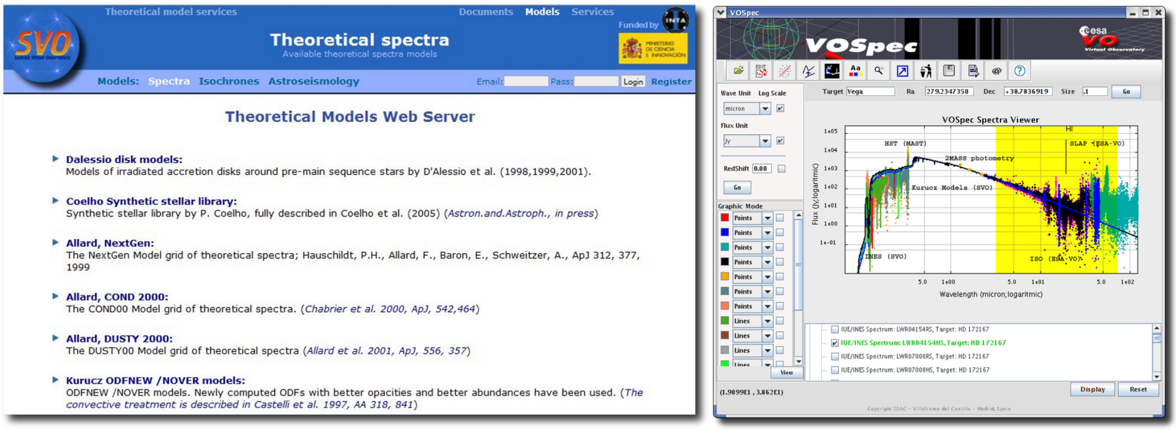

Figure 1: The TSAP server at CAB provides access to several collections of theoretical models. VOSpec, in the other hand, is a VO application able to access theoretical models using TSAP.

3 S3: generalization to other types of data

The same approach used in TSAP can be generalized to include theoretical models for other kind of data. This was done in the S3 protocol[9] still under consideration in the IVOA theory group.

The protocol is designed with two main principles in mind:

- Simplicity: The simpler the development of the service is, the more people will be willing to implement it (which is important as many theoretical models are developed by small groups focused in science).

- Flexibility: Self-described data/service.

Using it, several services have already been implemented not only for quite simple models like isochrones and evolutionary tracks ([2, 3, 1, 7], BaSTI[10]) or synthetic photometry for different models and filters, but also for the much more complex case of asteroseismology models [5, 8, 6].

These services are being used by applications focused in science, like VOSA[11] (see Fig. 2), using synthetic photometry, isochrones and evolutionary tracks services to estimate physical properties of observed objects and already used for science [4] or VOTA[12] (see Fig. 3), allowing to study asteroseismology models to analyze this kind of data.

[9] S3 note: http://www.ivoa.net/Documents/latest/S3TheoreticalData.html
[10] http://albione.oa-teramo.inaf.it
[11] http://svo.cab.inta-csic.es/theory/vosa
[12] http://svo.cab.inta-csic.es/theory/vota

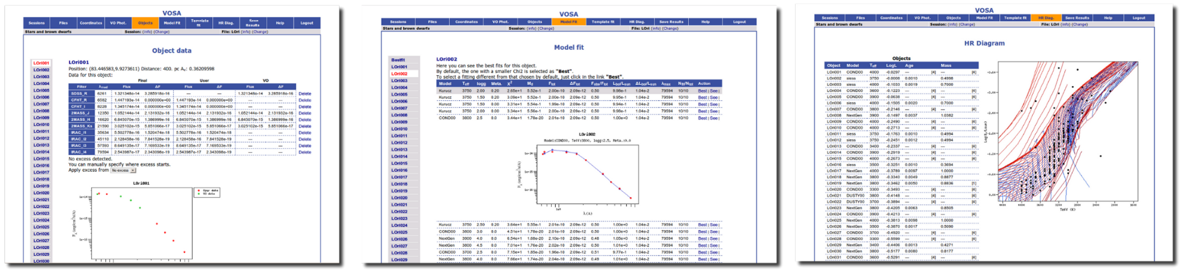

Figure 2: VOSA uses observed photometry (provided by the user or obtained from the VO), and comparing it with synthetic photometry from theoretical models, isochrones and evolutionary tracks, estimates values for the physical properties of the observed objects.

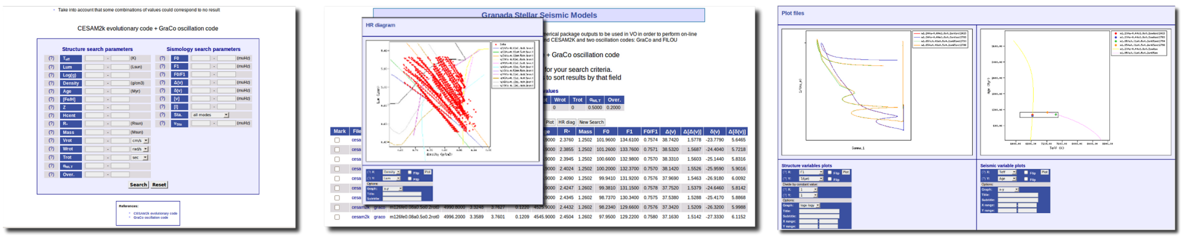

Figure 3: VOTA access different collections of asteroseismology models so that it is easy to explore the models, make selections on the basis of stellar structure or pulsational properties and make several kind of plots.

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