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Theoretical models access with a TSAP-like protocol

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Abstract. Although full interoperability between theoretical and observational data in the framework of the Virtual Observatory (VO) 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 for the case of theoretical spectra and has been included in the SSAP specification as a use case, providing a simple scheme to easily operate with this kind of data. The same philosophy is useful not only for synthetic spectra but also for other types of theoretical data. Following that idea, S3 (Simple Self-described Service protocol) has been proposed as an generalization of TSAP for other kind of theoretical models. For instance, S3 has been used to give access to theoretical isochrones and evolutionary tracks collections and synthetic photometry data. Finally, we pay special attention to the correct treatment of the credits, an important issue in the field of theoretical models.

Key words. Virtual Observatory - Theory

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 (VO) 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,

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Cone-Search,..., all of them require the object position and 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 and Euro-VO Theory Groups.

2. TSAP: A simple protocol

TSAP is simple protocol to access theoretical spectra. It was initially developed as a collaboration between ESA-VO[1] and SVO[2] 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[3].

TSAP can be described as a dialog 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.

3. TSAP: a working protocol

TSAP is not just an interesting idea, it is a working protocol.

3.1. Servers of theoretical models using TSAP

There are several servers of theoretical models using TSAP:

- LAEFF theoretical model server[4]. See Fig. 1.
- PGos3[5], developed by the INAOE (Mxico), which includes most of public SSP models and make them available using TSAP.
- PEGASE[6]

All of them, together with the web interface, accept http get queries according to the TSAP especification.

3.2. Applications accessing models using TSAP

VOSpec[7], a VO application designed to plot spectra obtained from the VO (and that also provides some analysis tools), gives the possibility to access theoretical spectra using TSAP and compare the observed ones. See Fig. 2.

4. S3: a TSAP generalization

Although TSAP was initially conceived for theoretical spectra, there is no reason why the same philosophy cannot be used for any other kind of theoretical data. The possibility of asking the service about *what are the parameters* over which queries can be performed (the basis

[1] `http://esavo.esa.int`
[2] `http://svo.laeff.inta.es`
[3] `http://www.ivoa.net/Documents/latest/SSA.html`
[4] `http://svo.laeff.inta.es/theory`
[5] `http://ov.inaoep.mx/pgos3/`
[6] `http://leda.univ-lyon1.fr/e31/`
[7] `http://esavo.esa.int/vospec/`

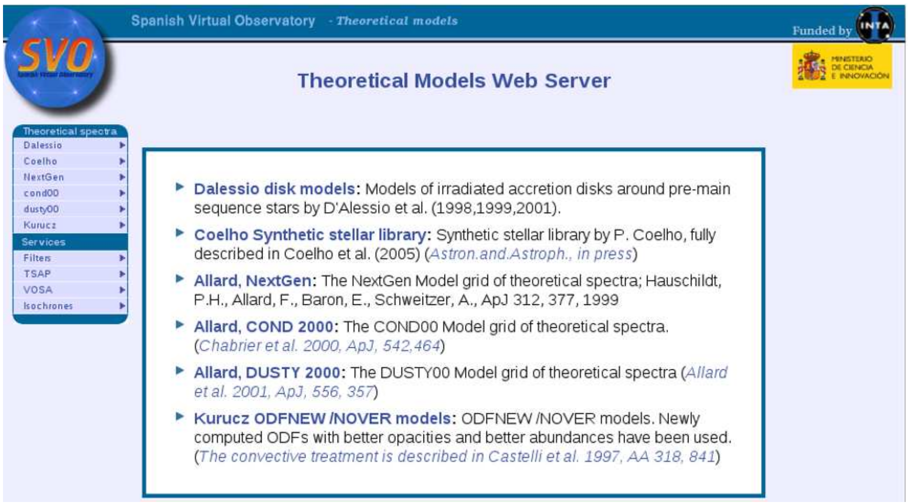

Fig. 1. The TSAP server at LAEFF provides access to several collections of theoretical models.

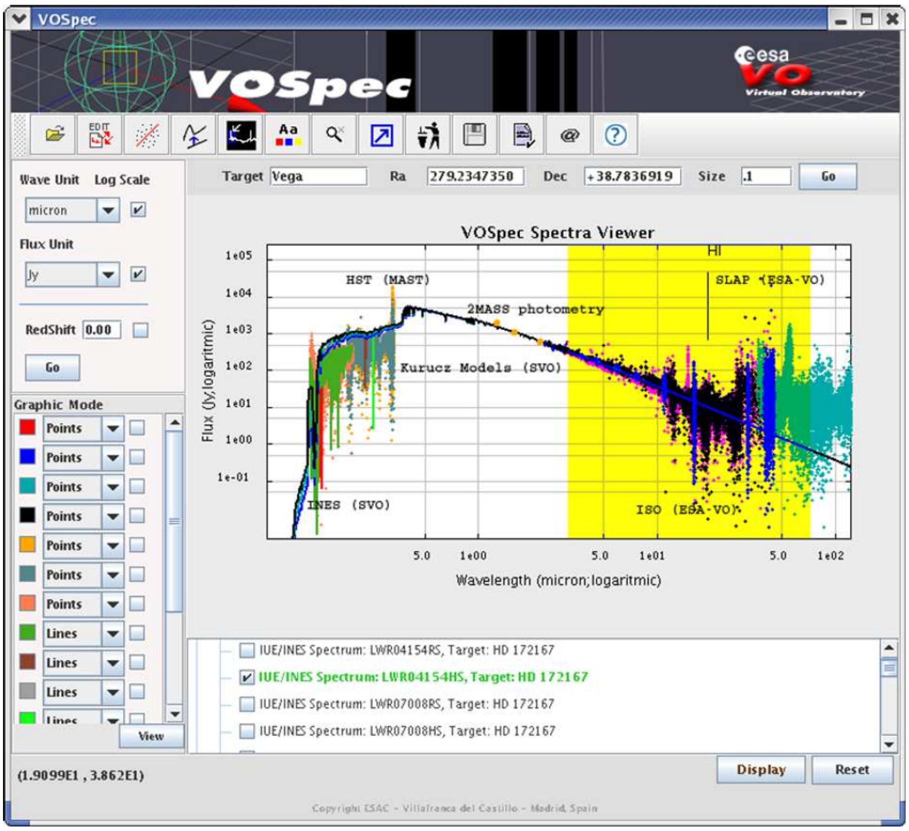

Fig. 2. VOSpec, a VO application able to access theoretical models using TSAP.

of TSAP) opens the VO to consult databases without the restriction of the name and/or a position in the sky.

Following this idea, S3[8][9] has been proposed as a protocol to handle theoretical data in the VO.

4.1. Isochrones and evolutionary tracks

We, at LAEFF, have developed an S3 service[10] to give access to isochrones and evolutionary tracks. Complementary to this, we have designed IDraw[11], a web application that uses S3 to access and download the data. The application also implements visualization tools that allow the user to overplot different set of theoretical models to his/her own observational data.

An S3 service has also been developed at INAF giving access to the BaSTI isochrones and evolutionary tracks[12].

4.2. Synthetic photometry

S3 has also been used to give access to a service providing synthetic photometry for 4 different collections of theoretical models and more than 150 different filters. It can be accessed using the S3 protocol via http get requests[13] or using the web interface[14].

5. Science using TSAP/S3

The physical properties of almost any kind of astronomical object can be derived by fitting synthetic spectra or photometry extracted from theoretical models to observational data.

(Bayo et al. 2008) study 170 candidate members to Collinder 69 using VOSA, a tool to analyze multiwavelength data in the VO framework. VOSA uses TSAP to access theoretical spectra to fit the observed photometry (and, therefore, to estimate effective temperatures, gravities and luminosities) and S3 to get theoretical isochrones and evolutionary tracks from the VO to infer masses and ages from a HR diagram.

This kind of studies of star forming regions, clusters, etc. produces a huge amount of data, very tedious to analyze using the traditional methodology. Thus, they are excellent examples where to apply the VO capabilities.

6. Building a VO server: S3wizard

Building a TSAP or S3 service from scratch is not difficult. The protocol is designed to make it as easy as possible.

However, a graphical web tool, S3wizard[15], has been developed so that a model developer can build a S3 server without programming at all.

S3wizard (Fig. 4) only needs the ASCII files containing the data corresponding to each model and user inputs about the meaning of parameters, data, columns, curation, credits... Everything is done through a web interface.

Using these inputs, the application builds the database, a web page with forms to download files in ASCII and VOTable formats and a VO service able to answer all the needed S3 queries.

7. Model credits and references

We would like to remark that, in the VO context, it is important that the user can recover easily the origin of the data and the processes and tools used to transform and analyze the original data.

This is particularly important in the case of theoretical models, both for:

– scientific reasons: the user must be aware of the technical details of the model that

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[8] `http://www.ivoa.net/Documents/latest/S3TheoreticalData.html`
[9] `http://svo.laeff.inta.es/wiki.php?page=S3`
[10] `http://svo.laeff.inta.es/theory/s3isocr`
[11] `http://svo.laeff.inta.es/theory/draw/getiso.php`
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[14] `http://svo.laeff.inta.es/theory/s3if`
[15] `http://svo.laeff.inta.es/wiki.php?page=S3wizard`

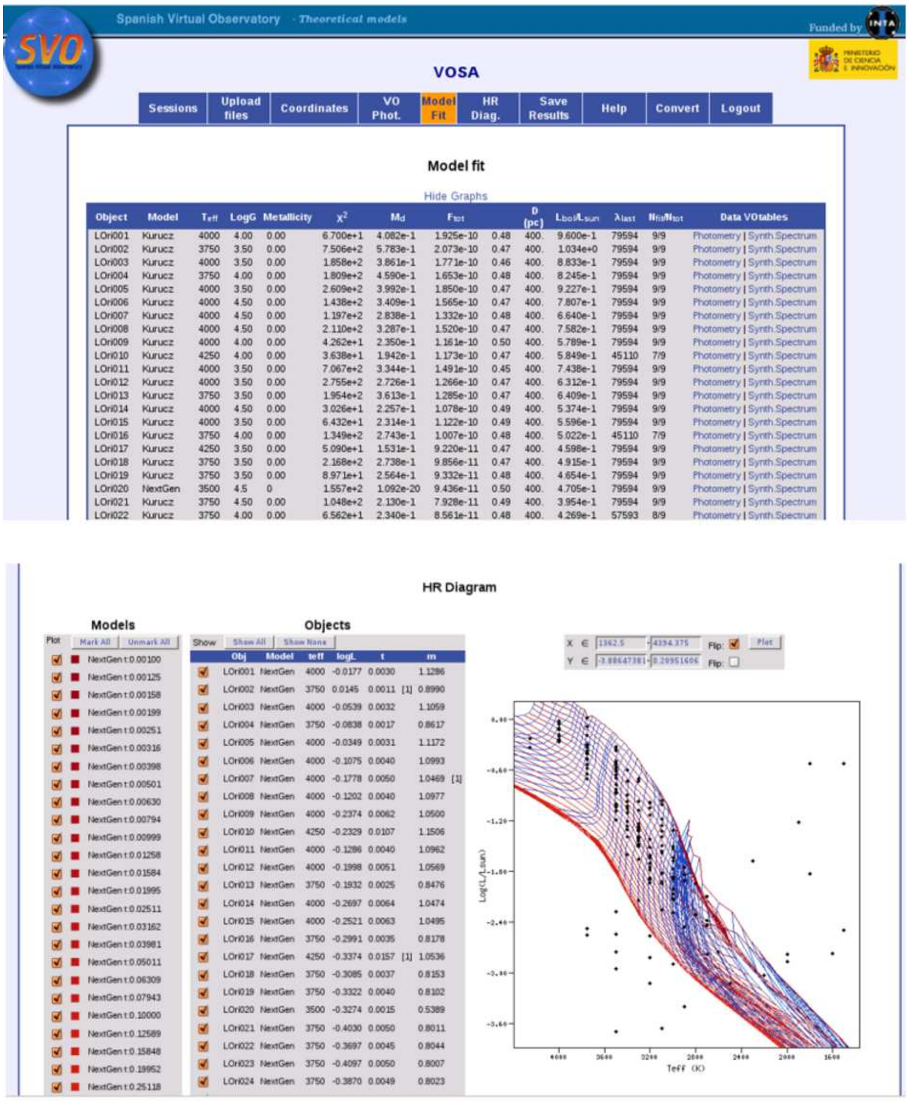

Fig. 3. VOSA: (i) Example of the table with the best fittings and the physical parameters suggested for the objects. (ii)HR diagram of the members of Collinder 69 and the suggested value for the age and mass of the objects.

he is using for his work (being able, for instance, to access a scientific paper with those details).

– adequately reference or acknowledge the scientific work and technical tools used, which is very relevant in order to encourage model developers to make available their work in the VO.

It seems clear that VO services should give that information in their VOTables. But it is also very important that any VO application

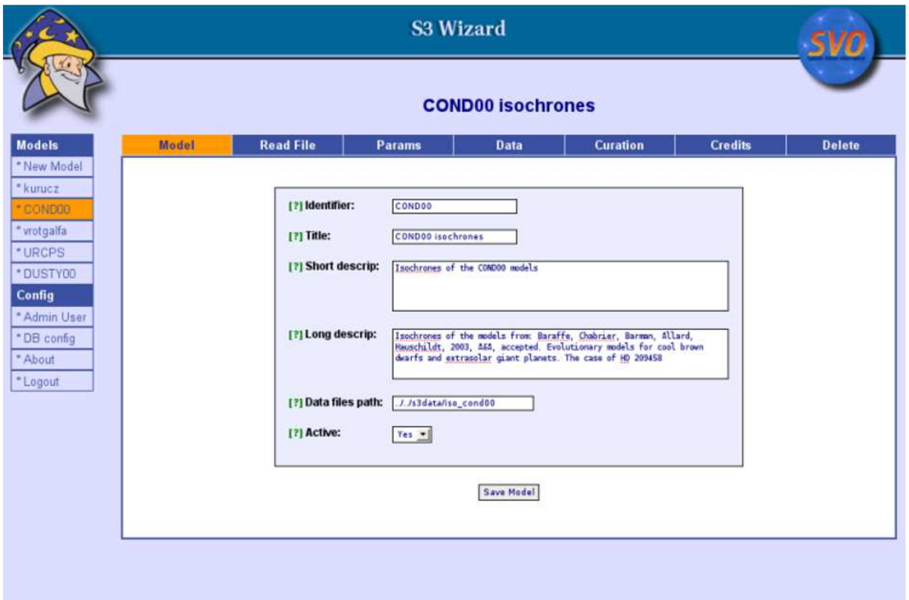

Fig. 4. S3wizard provides an easy interface to configure all the necessary properties of a model.

keeps track of the information related to the data it uses, includes all of it in the resulting VOTables and gives an easy way to the final user to recover that information (a ”get credits” button?).

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