



# Theoretical models in the VO

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Euro-VO AIDA Workshop,  
How to publish data in the VO  
Madrid , June 22 -26, 2009



# What is the VO?

- An international effort in astrophysics for:
  - **Standardization**
    - common data formats (VOTable, Data Models,...)  
(how the data are represented, written...)
  - **Interoperability**
    - common protocols (SIAP, SSAP, TSAP...)  
(how to make questions and how to answer them)



# Theoretical Models not in VO

Theoretical models available in internet:

- as a collection of files
- search form → file
- ASCII or FITS files
- special data format for each model



# Theoretical Models not in VO

Theoretical models available in internet:

- as a collection of files

- search from file

- ASCII o

- special

## Kurucz/Grids of model atmospheres

Naming scheme:

Suffix

H01 = [-0.1] log metal abundance re  
 P00 = [+0.0] solar abundances from  
 P05 = [+0.5] log metal abundance re  
 A = alpha enhanced, the alpha-pr  
 S, Ar, Ca, and Ti) enhanced b  
 B = alpha enhanced, the alpha-pr  
 S, Ar, Ca, and Ti) enhanced b  
 F = solar Fe abundance reduced to  
 HE = He number fraction specified  
 Y = He mass fraction specified in  
 NOVER = models with no convective ove  
 Castelli [castelli@ts.astro.i  
 treatment is described in Cas  
 A&A 328, 841. Some colors ar  
 labelled coubes\* are Cousins  
 instead of the obsolete Besse  
 calculations.  
 ODFNEW = as NOVER but with newly computed ODFs with better opacities  
 and better abundances. (Consult Castelli; paper in preparation)  
 \*\*THESE ARE THE PREFERRED MODELS\*\*

Prefix

A = tables of temperatures-pressure relations for each model for a range  
 Teff and log gravity  
 B = Balmer line profiles for each model  
 F = fluxes for each model  
 I = intensities for each model; limbdarkening for 17 angles

## Index of /grids/gridm25ODFNEW/

Name	Last modified	Size	Description
<a href="#">_Parent Directory</a>			
<a href="#">_aa25k2odfnew.dat</a>	04-Nov-03 17:55	4M	
<a href="#">_coubes*25k2odfnew.dat</a>	04-Nov-03 17:55	42K	
<a href="#">_fa25k2odfnew.pck</a>	04-Nov-03 17:55	11M	
<a href="#">_rjklq25k2odfnew.dat</a>	04-Nov-03 17:56	61K	
<a href="#">_ubv*25k2odfnew.dat</a>	04-Nov-03 17:56	50K	
<a href="#">_uvby*25k2odfnew.dat</a>	04-Nov-03 17:56	61K	



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# Theoretical Models not in VO

Theoretical models available in internet:

- as a collection of files
- search form → file

**SPECTRAL LIBRARY 1Å**

This database contains the subset of spectra with a 1Å uniform dispersion from the spectral library presented in the article by U. Munari, R.Sordo, F.Castelli and T.Zwitter, "An extensive library of 2500-10500 Å synthetic spectra", A&A (2005). Please refer to this document for a detailed explanation of the content of the SpectralLib 1Å database.

Provide parameter values for search in SpectralLib 1Å database:

Temperature: 1  K

Rotation velocity: 1  km s<sup>-1</sup>

Metallicity: 1

Gravity: 1

$\alpha$ -Enhancement ( $\alpha/\text{Fe}$ ): 1

Micro-turbulence: 1  km s<sup>-1</sup>

Spectrum type: 1

For the given parameters 1 FITS file has been found:

Temperature (K)	3750
Rotation Velocity (km s <sup>-1</sup> )	5
Metallicity	+0
Gravity (log g)	1.5
$\alpha$ -Enhancement	0.0
Micro-turbulence (km s <sup>-1</sup> )	2
Fluxed spectrum/ Normalized	Fluxed spectrum

No overshooting/New ODF model applied:  FITS file: T03750G1SP00V00Sk2SHWV001F.fits   [\(created by SpectoVis\)](#)



# Theoretical Models not in VO

Theoretical models available in internet:

- as a collection of files
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- ASCII or FITS files
- special data format for each model



# Theoretical Models not in VO

- It's **difficult** to **compare models** with each other and to compare them with observational data.
- It's **difficult** to **develop tools** that work with several different models.
- It's **impossible** to develop generic tools able to work with theoretical models **on-the-fly**.





# Theoretical Models in VO

- **Final aim:** Full interoperability between observational and theoretical data.
- Efficiency
  - easier and faster to **compare models** with observations and with other models.
  - easier characterization
- Visibility
  - More people will have an **easier access** to the models.
  - The models will, eventually, be **more used** and referenced.



# Theoretical models in VO?

- **VO protocols for observational data**
  - (ConeSearch, SIAP, SSAP,...)
  - are built around coordinates and/or real objects.
    - <http://.../ssap.jsp?POS=336.5228,-48.43854&SIZE=0.2>
  - **Not valid for theoretical models.**



# Theoretical models in VO?

- **A theoretical model:**

- Is not related with a real object or with spatial coordinates.
- Is defined by a set of parameters and the allowed values for each of them.
- Those parameters and values are not the same for different models.
- Even models describing similar physics are often characterized using different types of parameters.



# Theoretical models in the VO

- **Theoretical spectra: TSAP**

- Included in the SSAP standard (use case for theoretical spectra)
- A **simple** protocol.
- **Dialog server-application.**
- Easy to develop.



# TSAP: a working protocol

- **Servers** of theoretical models with TSAP
  - LAEFF, Pgos3(Mex), PEGASE, etc
  - Kurucz, NextGen, COND, DUSTY, PEGASE, Dalessio, etc...
- **Applications** accessing TSAP services
  - VOSpec
- **Analysis** tools
  - VOSed, VOSA
- **Science** with VO using TSAP
  - SED analyzer for the case of Collinder 69 (Bayo et al 2008)



# TSAP Server (LAEFF)

Spanish Virtual Observatory - Theoretical models

Funded by INTA

## Theoretical Models Web Server

**Theoretical spectra**

- Dallessio
- Kurucz
- Coelho
- NextGen
- cond00
- dusty00

**Services**

- TSAP
- Photometry fit
- isochrones

- ▶ **Dallessio disk models:** Models of irradiated accretion disks around pre-main sequence stars by D'Alessio et al. (1998,1999,2001).
- ▶ **Kurucz ODFNEW /NOVER models:** ODFNEW /NOVER models. Newly computed ODFs with better opacities and better abundances have been used. (*The convective treatment is described in Castelli et al. 1997, AA 318, 841*)
- ▶ **Coelho Synthetic stellar library:** Synthetic stellar library by P. Coelho, fully described in Coelho et al. (2005) (*Astron. and Astroph., in press*)
- ▶ **Allard, NextGen:** The NextGen Model grid of theoretical spectra; Hauschildt, P.H., Allard, F., Baron, E., Schweitzer, A., ApJ 312, 377, 1999
- ▶ **Allard, COND 2000:** The COND00 Model grid of theoretical spectra. (*Chabrier et al. 2000, ApJ, 542,464*)
- ▶ **Allard, DUSTY 2000:** The DUSTY00 Model grid of theoretical spectra (*Allard et al. 2001, ApJ, 556, 357*)

Version 0.1 - Mar 2005

Home - SVO - LAEFF



# Using TSAP: VOSpec

The screenshot displays the VOSpec application interface. The main window has a menu bar (File, Edit, View, Operations, Plastic, SAMP, Help) and a toolbar. The left sidebar contains controls for Wave Unit (micron), Flux Unit (Jy), Redshift (0.00), De-reddening, and  $\lambda/V$  (0.00). The main area shows a 'Target' field with 'vega' and coordinates (Ra: 279.234735, Dec: 836919). A 'Spectra List' panel is at the bottom.

Overlaid on the main window are two panels:

- Server Selector:** A tree view under 'Query by Service' showing 'Green services support params selected'. The 'Theoretical Spectra Services' folder is expanded, with 'PGos3: Evolutionary synthesis models' selected. Other services listed include X-ray service prototype, VO-Mexico Model: Sternberg, VO-Mexico Model: UCL, ATLAS9 Kurucz ODFEW/HOVER model, Coelho Synthetic stellar library, Models of irradiated accretion disk, PopStar evolutionary synthesis model, TMAP SSA service, and VO-Paris: PEGASE.HR synthetic spectra.
- Query by params:** A tree view showing a query for 'vega' with parameters: 'POS 279.234735, 36.7836919444' and 'SIZE 1'. Below the tree is an 'Insert Param Value' section with a 'Text Param' input field and an 'Add' button. At the bottom are 'Query' and 'Reset' buttons.

At the bottom of the application window, there is a 'Query Outlook' panel with an 'Add SSA/TSA locally' button and a 'Select All' checkbox. Below this are two URL fields: `http://ov.jnaoep.mv.it/sap/SyntMod.php?` and `http://ov.jnaoep.mv.it/sap/SyntMod.php?`.





# Using TSAP: VOSpec

The screenshot displays the VOSpec software interface, which is used for viewing and analyzing spectra. The main window, titled "VOSpec Spectra Viewer", shows a plot of Flux (Jy/logarithmic) versus Wavelength (micron, logarithmic). The plot includes several data series: "BBT (MAGP)", "2MASS photometry", "Kuznetsov Models (SVO)", "ISO (ESA-VO)", and "SLAP (ESA-VO)". The plot is divided into two color-coded regions: a yellow region on the left and a blue region on the right.

The interface includes several control panels:

- Target Vega:** Ra 279.2347350, Dec +38.7836919, Size .1, Go
- Wave Unit:** micron, Log Scale checked
- Flux Unit:** Jy, Red Shift 0.00
- Graphic Mode:** A list of models and lines to be displayed, including "Points" and "Lines" for various models like "BBT (SVO)", "2MASS (SVO)", "Kuznetsov Models (SVO)", "ISO (SVO)", "SLAP (SVO)", "BBT (MAGP)", "2MASS photometry", "Kuznetsov Models (SVO)", "ISO (ESA-VO)", and "SLAP (ESA-VO)".

At the bottom of the window, there is a list of spectra to be displayed:

- IUE/INES Spectrum: LWR04154RS, Target: HD 172167
- IUE/INES Spectrum: LWR04154HS, Target: HD 172167
- IUE/INES Spectrum: LWR07008RS, Target: HD 172167
- IUE/INES Spectrum: LWR07008HS, Target: HD 172167

Buttons for "Display" and "Reset" are located at the bottom right of the plot area. The bottom status bar shows the coordinates (1.9899E1, 3.862E1) and the copyright information: "Copyright ESAC - Villaverde del Castillo - Madrid, Spain".



# TSAP in real life: VO-Science

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DOI: 10.1051/0004-6361:200810395  
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**Astronomy  
&  
Astrophysics**

## **VOSA: virtual observatory SED analyzer** **An application to the Collinder 69 open cluster\***

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# More general protocols for theory

(under development)

- **SimDB/SimDAP.**
  - Complex data model + protocol.
  - Designed for 3+1 (“cosmological”) simulations.
  - In the process to be extended to microsimulations.
- **S3.**
  - Same approach than TSAP.
  - Designed for microsimulations.
  - A simple protocol.
- Trying to converge.



# Using SimDB/SimDAP

- Cosmological simulations
  - Prototypes for GalMER, Horizon
- PDR simulations
  - Test implementation of Meudon PDR code
- Isochrones/evolutionary tracks
  - BaSTI
- Visualization tools
  - VisIVO



# Using S3

- Servers for isochrones and evolutionary tracks
  - NextGen, COND, DUSTY, Siess (SVO)
  - BaSTI (IVO)
- Synthetic photometry for different models
  - NextGen, COND, DUSTY, Kurucz...
- Analysis tools using S3 data
  - VOSA
- Astrosismology models
  - *in progress*

# Using S3: VOSA

**VOSA**

Sessions	Upload files	Coordinates	VO Phot.	Model Fit	Template fit	HR Diag.	Save Results	Help	Logout
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## HR Diagram

**Choose the parameter ranges that you want to use for the diagram**

**NextGen Isochrones**  
*Theoretical Evolutionary Tracks from Baraffe, Chabrier, Allard, Hauschildt, 1998, A&A, 337, 403 "Evolutionary models for solar metallicity low-mass stars: mass-magnitude relationships and color-magnitude diagrams" and Baraffe, Chabrier, Allard, Hauschildt, 2001, A&A, accepted "Evolutionary models for low-mass stars and brown dwarfs: uncertainties and limits at very young ages"*


**t:**  -  (Min/Max value for the age of the star.  
Ages are given in Gyr)

**NextGen Evolutionary Tracks**  
*Theoretical Evolutionary Tracks from Baraffe, Chabrier, Allard, Hauschildt, 1998, A&A, 337, 403 "Evolutionary models for solar metallicity low-mass stars: mass-magnitude relationships and color-magnitude diagrams" and Baraffe, Chabrier, Allard, Hauschildt, 2001, A&A, accepted "Evolutionary models for low-mass stars and brown dwarfs: uncertainties and limits at very young ages"*

**m:**  -  (Min/Max value for the mass of the star.  
Masses are given in Msun)

**DUSTY99 Isochrones**  
*Theoretical Evolutionary Tracks from Chabrier, Baraffe, Allard, Hauschildt, 2000, ApJ, 542, 464 "Evolutionary models for very-low-mass stars and brown dwarfs with dusty atmospheres" and Baraffe, Chabrier, Allard, Hauschildt, 2002, A&A, 382, 563 "Evolutionary models for low-mass stars and brown dwarfs: uncertainties and limits at very young ages"*

**t:**  -  (Min/Max value for the age of the star. Ages are given in Gyr)



# Using S3: VOSA

**VOSA**

Sessions   Upload files   Coordinates   VO Phot.   Model Fit   Template fit   **HR Diag.**   Save Results   Help   Logout

## HR Diagram

**Models**

Plot	Mark All	Unmark All
<input checked="" type="checkbox"/>	NextGen1.0.00100	
<input checked="" type="checkbox"/>	NextGen1.0.00125	
<input checked="" type="checkbox"/>	NextGen1.0.00158	
<input checked="" type="checkbox"/>	NextGen1.0.00189	
<input checked="" type="checkbox"/>	NextGen1.0.00251	
<input checked="" type="checkbox"/>	NextGen1.0.00316	
<input checked="" type="checkbox"/>	NextGen1.0.00398	
<input checked="" type="checkbox"/>	NextGen1.0.00501	
<input checked="" type="checkbox"/>	NextGen1.0.00630	
<input checked="" type="checkbox"/>	NextGen1.0.00794	
<input checked="" type="checkbox"/>	NextGen1.0.00999	
<input checked="" type="checkbox"/>	NextGen1.0.01258	
<input checked="" type="checkbox"/>	NextGen1.0.01584	
<input checked="" type="checkbox"/>	NextGen1.0.01995	
<input checked="" type="checkbox"/>	NextGen1.0.02511	
<input checked="" type="checkbox"/>	NextGen1.0.03162	
<input checked="" type="checkbox"/>	NextGen1.0.03981	
<input checked="" type="checkbox"/>	NextGen1.0.05011	
<input checked="" type="checkbox"/>	NextGen1.0.06309	
<input checked="" type="checkbox"/>	NextGen1.0.07943	
<input checked="" type="checkbox"/>	NextGen1.0.10000	
<input checked="" type="checkbox"/>	NextGen1.0.12589	
<input checked="" type="checkbox"/>	NextGen1.0.15848	
<input checked="" type="checkbox"/>	NextGen1.0.19952	
<input checked="" type="checkbox"/>	NextGen1.0.25118	

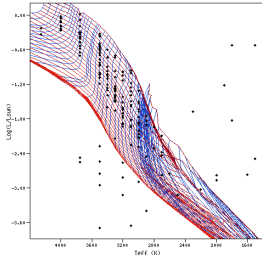
**Objects**

Obj	Model	logg	logL	t	m
LOh001	NextGen	4000	-0.0177	0.0030	1.1286
LOh002	NextGen	3750	0.0145	0.0011	[1] 0.8990
LOh003	NextGen	4000	-0.0539	0.0032	1.1059
LOh004	NextGen	3750	-0.0838	0.0017	0.8617
LOh005	NextGen	4000	-0.0349	0.0031	1.1172
LOh006	NextGen	4000	-0.1075	0.0040	1.0993
LOh007	NextGen	4000	-0.1778	0.0050	1.0489 [1]
LOh008	NextGen	4000	-0.1202	0.0040	1.0977
LOh009	NextGen	4000	-0.2374	0.0062	1.0500
LOh010	NextGen	4250	-0.2329	0.0307	1.1506
LOh011	NextGen	4000	-0.1286	0.0040	1.0992
LOh012	NextGen	4000	-0.1998	0.0051	1.0669
LOh013	NextGen	3750	-0.1932	0.0025	0.8476
LOh014	NextGen	4000	-0.2997	0.0094	1.0474
LOh015	NextGen	4000	-0.2521	0.0093	1.0495
LOh016	NextGen	3750	-0.2991	0.0035	0.8179
LOh017	NextGen	4250	-0.3374	0.0257 [1]	1.0536
LOh018	NextGen	3750	-0.3095	0.0037	0.8153
LOh019	NextGen	3750	-0.3322	0.0040	0.8202
LOh020	NextGen	3900	-0.3274	0.0015	0.5389
LOh021	NextGen	3750	-0.4000	0.0050	0.8011
LOh022	NextGen	3750	-0.3697	0.0045	0.8044
LOh023	NextGen	3750	-0.4097	0.0050	0.8007
LOh024	NextGen	3750	-0.3870	0.0049	0.8023

HR Diagram

X  $\in$  [242.2]   208.378   Plot  Plot

Y  $\in$  [3.084728]   0.2091436   Plot  Plot







# Using S3: Astroseismology

Theoretical model services
Documents Models Services
Funded by

## Astroseismology

Granada Stellar Seismic Models

Models: Spectra Isochrones **Astroseismology**
cb@laef.inta.es Admin Uploads LogOut

Granada Stellar Seismic Models

**Structure variables plots**

(?) X:

(?) Y:

Divide by constant value:

(?) X:

(?) Y:

Graph:

please, mark 5 files at most

- (?) m1.20fe-0.40a1.8o0.2om0saA1000
- (?) m1.20fe-0.40a1.8o0.2om0saA920
- (?) m1.85fe0.01a0.5o0.2om65saA1030
- (?) m1.85fe0.01a0.5o0.2om65saA790

**Seismic variable plots**

(?) X:

(?) Y:

Graph:



# Using S3: BaTSI



## Micro-simulations inside the VO: the BaSTI case



P. Manzano<sup>(1)</sup>, M. Molinaro<sup>(1)</sup>, F. Gasparo<sup>(1)</sup>, F. Pasian<sup>(1)</sup>, A. Pietrinferni<sup>(2)</sup>, S. Cassisi<sup>(3)</sup>, C. Rodrigo<sup>(3)</sup>, M. Cerviño<sup>(4)</sup>, E. Solano<sup>(3)</sup>  
 INAF - SI / Trieste Astronomical Observatory; (2) INAF - Teramo Astronomical Observatory; (3) LAEFF-INTA / Spanish VO; (4) Instituto de Astrofísica de Andalucía - CSIC / Spanish VO

### S3P (Simple Self-Described Service Protocol) implementations

In collaboration with SVO (the Spanish Virtual Observatory) we presented S3P in the last IVOA Interoperability Meeting. S3P (Simple, Self-described Service) is a protocol oriented to handle theoretical data in the VO framework. It is based in the ability of the data server to describe itself in a simple standardized way.

This is a step by step protocol:

- 1 step: the service described it self (input and output parameters);  
<http://myservice.com/s3.php?format=metadata>
- 2 step: http query and response in VOTable format;  
<http://myservice.com/s3.php?param1=value1&param2=value2...>
- 3 step: retrieve the simulated files of interest via http GET;  
<http://myservice.com/s3.php?id=12>

We developed two prototype implementations of S3P for BaSTI: one for isochrones and one for tracks:

<http://albione.ca-teramo.inaf.it/PHPmetadata/BaSTIisochron.php?format=metadata>  
<http://albione.ca-teramo.inaf.it/PHPmetadata/BaSTItrack.php?format=metadata>



Parameters	Units	Description
INPUT_age_min	time age	Min. age of the isochron in Gyr (min value 0.0) Gyr
INPUT_age_max	time age	Max. age of the isochron in Gyr (max value 19 Gyr)
INPUT_metal_min	phys.abund.Z	Min. mass fraction of the initial heavy elements abundance for stellar isochron model (min value 0.0001)
INPUT_metal_max	phys.abund.Z	Max. mass fraction of the initial heavy elements abundance for stellar isochron model (max value 0.4)
OUTPUT_age	time age	value for the stellar Age for the model. Age is given in Gyr
OUTPUT_metal	phys.abund.Z	value of mass fraction of the initial heavy elements abundance for the model.
OUTPUT[MH]	phys.abund.Fe	The metal abundance in the spectroscopic formation.
OUTPUT[Fe/H]	phys.abund.Fe	The iron abundance in the spectroscopic formation.
OUTPUT_Y	phys.abund.Y	value of mass fraction of the initial helium abundance. Actually calculated as $Y = 1 + 4(X - Z) / 0.001$ .
OUTPUT_MassLoss	phys.mass.loss	value of mass loss according to the Reimers (1975) law.
OUTPUT_title	FOV.Image_Title	Title



THANK YOU!