Theoretical models in the VO

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Outline

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 $\longrightarrow$ file
- ASCII or FITS files

- special data format for each model

Theoretical Models not in VO

Kurucz/Grids of model atmospheres

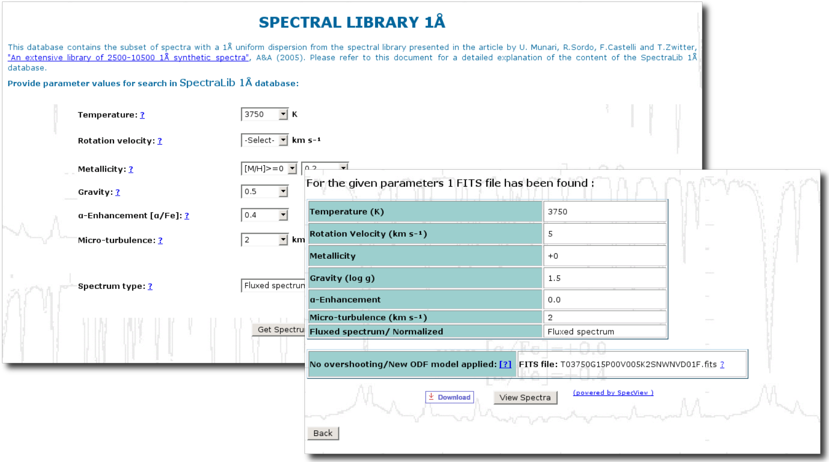
```
Naming scheme:
Suffix
   M01 = [-0.1} log metal abundance relative to solar
   P00 = [+0.0] solar abundances from Anders and Grevesse (    )
   P05 = [+0.5] log metal abundance relative to solar
     A = alpha enchanced, the alpha-process elements (O, Ne, Mg, Si,
         S, Ar, Ca, and Ti) enhanced by +0.4 in the log and Fe -4.53
     B = alpha enchanced, the alpha-process elements (O, Ne, Mg, Si,
         S, Ar, Ca, and Ti) enhanced by +1.0 in the log and Fe -4.53
     F = solar Fe abundance reduced to current value -4.51
    HE = He number fraction specified in per cent
     Y = He mass fraction specified in per cent
 NOVER = models with no convective overshooting computed by Fiorella
         Castelli [castelli@ts.astro.it] in Trieste. The convective
         treatment is described in Caste
         A&A 328, 841.  Some colors are
         labelled coubes* are Cousins wi
         instead of the obsolete Bessell
         calculations.
ODFNEW = as NOVER but with newly compute
         and better abundances. (Consult
         **THESE ARE THE PREFERRED MODEL

Prefix
A = tables of temperatures-pressure rel
    Teff and log gravity
B = Balmer line profiles for each model
F = fluxes for each model
I = intensities for each model; limbdar
```

Index of /grids/gridm25ODFNEW/

Name	Last modified	Size	Description
Parent Directory			
am25k2odfnew.dat	04-Nov-03 17:55	4M	
coubesm25k2odfnew.dat	04-Nov-03 17:55	42K	
fm25k2odfnew.pck	04-Nov-03 17:55	11M	
rijklm25k2odfnew.dat	04-Nov-03 17:56	61K	
ubvm25k2odfnew.dat	04-Nov-03 17:56	50K	
uvbym25k2odfnew.dat	04-Nov-03 17:56	61K	

Theoretical Models not in VO



U. Munari, R.Sordo, F.Castelli and T.Zwitter, "An extensive library of 2500-10500 1Å synthetic spectra", A&A (2005)

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.

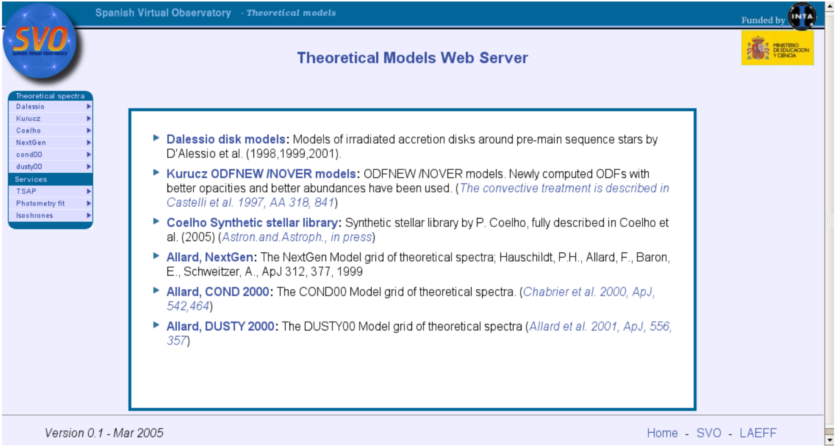
Theoretical models in the VO

- **TSAP**
  - A simple protocol.
  - Dialog server-application.
  - Started as a collaboration ESAVO-SVO.
  - Included in the SSAP standard (for theoretical spectra)
  - Easy to develop.
  - Valid for other kind of data.
- **SNAP.**
  - Complex protocol.
  - designed for cosmological simulations.

TSAP: a working protocol

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

TSAP Server (LAEFF)


Spanish Virtual Observatory - *Theoretical models*

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Theoretical Models Web Server

Theoretical spectra
- Dalessio
- Kurucz
- Coelho
- NextGen
- cond00
- dusty00

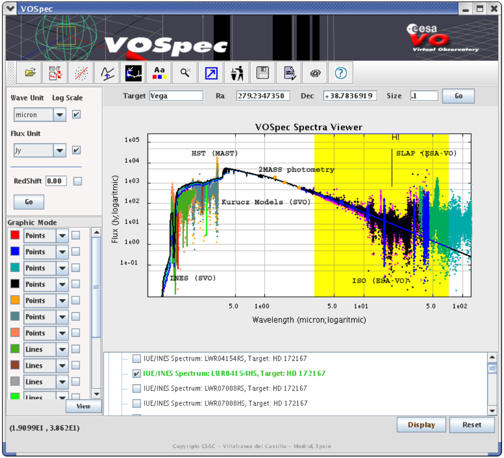
Services
- TSAP
- Photometry fit
- Isochrones

- **Dalessio 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



Isochrones

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Theoretical spectra
- Dalessio
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- cond00
- dusty00

Services
- TSAP
- Photometry fit
- Isochrones

Isochrone and Evolutionary Tracks Services

- COND99 isochrones

  Baraffe, Chabrier, Barman, Allard, Hauschildt, 2003, A&A, accepted "Evolutionary models for cool brown dwarfs and extrasolar giant planets. The case of HD 209458"

- COND99 evol. tracks

  Baraffe, Chabrier, Barman, Allard, Hauschildt, 2003, A&A, accepted "Evolutionary models for cool brown dwarfs and extrasolar giant planets. The case of HD 209458"

- DUSTY99 isochrones

  Chabrier, Baraffe, Allard, Hauschildt, 2000, ApJ,542, 464 "Evolutionary models for very-low-mass stars and brown dwarfs with dusty atmospheres"
  Baraffe, Chabrier, Allard, Hauschildt, 2001, A&A, 382, 563 "Evolutionary models for low-mass stars and brown dwarfs: uncertainties and limits at very young ages"

- DUSTY99 evol. tracks

  Chabrier, Baraffe, Allard, Hauschildt, 2000, ApJ,542, 464 "Evolutionary models for very-low-mass stars and brown dwarfs with dusty atmospheres"
  Baraffe, Chabrier, Allard, Hauschildt, 2001, A&A, 382, 563 "Evolutionary models for low-mass stars and brown dwarfs: uncertainties and limits at very young ages"

- 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"

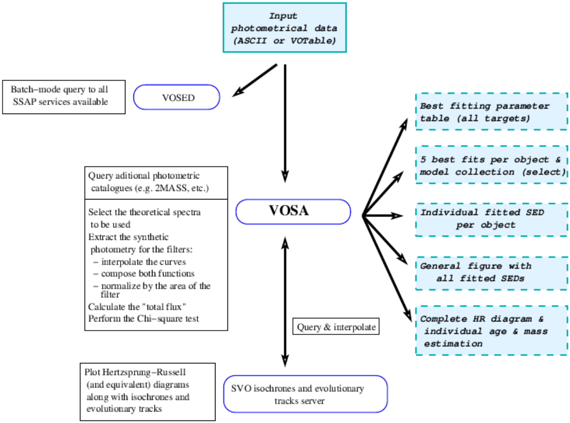
Science using TSAP/S3

VOSA: The VO Spectral Energy Distribution analyzer.
The case of the young cluster Collinder 69
(Bayo et al, 2008)

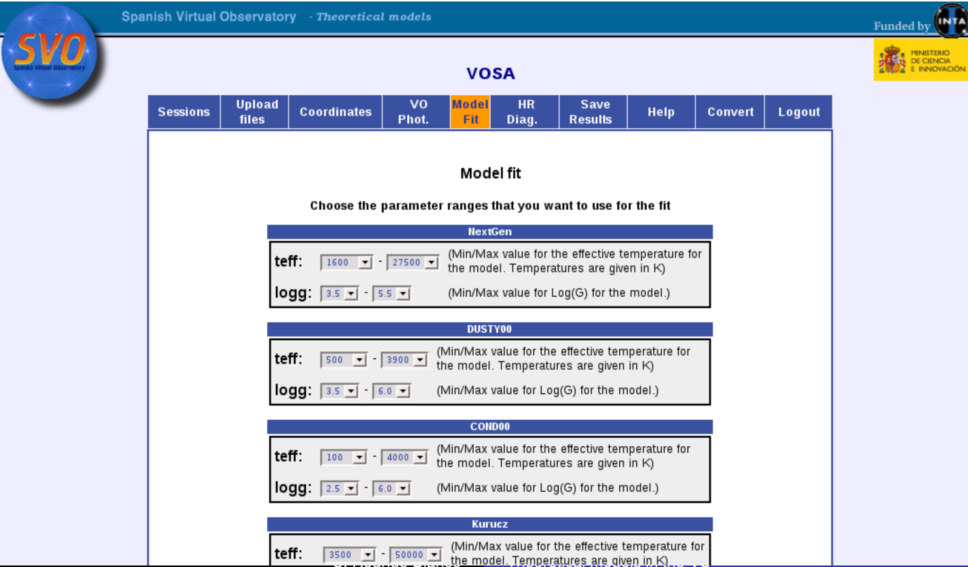
- IRAC photometry for 167 candidate members of C69.
- VO archival data research (multi-wavelength range).
- Three different collections of theoretical models (with TSAP and S3).
- Determination of the best physical parameters for the objects and the association (T_{eff}, gravity, mass and age)

- A difficult task without using the VO.
- Much easier using VO tools.

VOSA: SED analysis using theoretical models



VOSA: SED analysis using theoretical models



VOSA: SED analysis using theoretical models

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VOSA

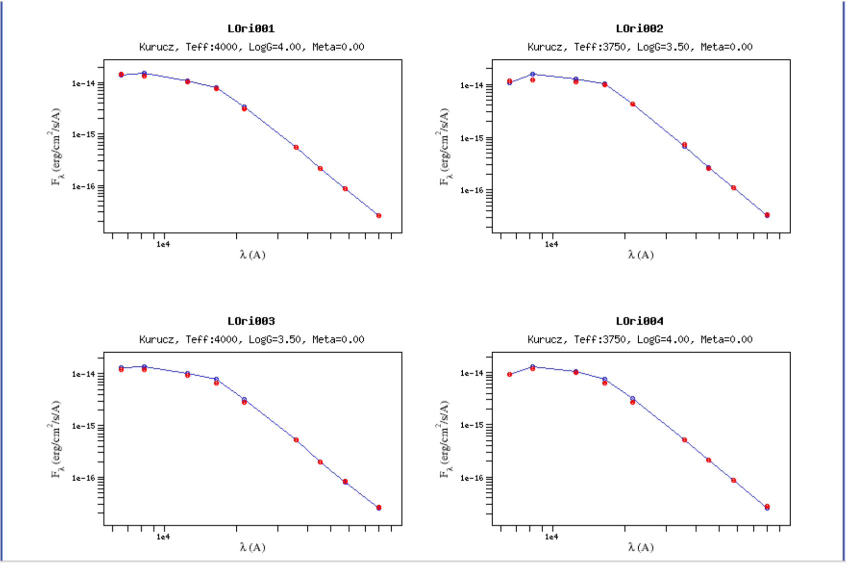
Sessions | Upload files | Coordinates | VO Phot. | Model Fit | HR Diag. | Save Results | Help | Convert | Logout

Model fit

Hide Graphs

Object	Model	T_{eff}	LogG	Metallicity	χ^2	M_d	F_{tot}		D (pc)	L_{bol}/L_{sun}	λ_{last}	N_{fit}/N_{tot}	Data VOtables
LOri001	Kurucz	4000	4.00	0.00	6.700e+1	4.082e-1	1.925e-10	0.48	400.	9.600e-1	79594	9/9	Photometry | Synth.Spectrum
LOri002	Kurucz	3750	3.50	0.00	7.506e+2	5.783e-1	2.073e-10	0.47	400.	1.034e+0	79594	9/9	Photometry | Synth.Spectrum
LOri003	Kurucz	4000	3.50	0.00	1.858e+2	3.861e-1	1.771e-10	0.46	400.	8.833e-1	79594	9/9	Photometry | Synth.Spectrum
LOri004	Kurucz	3750	4.00	0.00	1.809e+2	4.590e-1	1.653e-10	0.48	400.	8.245e-1	79594	9/9	Photometry | Synth.Spectrum
LOri005	Kurucz	4000	3.50	0.00	2.609e+2	3.992e-1	1.850e-10	0.47	400.	9.227e-1	79594	9/9	Photometry | Synth.Spectrum
LOri006	Kurucz	4000	4.50	0.00	1.438e+2	3.409e-1	1.565e-10	0.47	400.	7.807e-1	79594	9/9	Photometry | Synth.Spectrum
LOri007	Kurucz	4000	4.50	0.00	1.197e+2	2.838e-1	1.332e-10	0.48	400.	6.640e-1	79594	9/9	Photometry | Synth.Spectrum
LOri008	Kurucz	4000	4.50	0.00	2.110e+2	3.287e-1	1.520e-10	0.47	400.	7.582e-1	79594	9/9	Photometry | Synth.Spectrum
LOri009	Kurucz	4000	4.00	0.00	4.262e+1	2.350e-1	1.161e-10	0.50	400.	5.789e-1	79594	9/9	Photometry | Synth.Spectrum
LOri010	Kurucz	4250	4.00	0.00	3.638e+1	1.942e-1	1.173e-10	0.47	400.	5.849e-1	45110	7/9	Photometry | Synth.Spectrum
LOri011	Kurucz	4000	3.50	0.00	7.067e+2	3.344e-1	1.491e-10	0.45	400.	7.438e-1	79594	9/9	Photometry | Synth.Spectrum
LOri012	Kurucz	4000	3.50	0.00	2.755e+2	2.726e-1	1.266e-10	0.47	400.	6.312e-1	79594	9/9	Photometry | Synth.Spectrum
LOri013	Kurucz	3750	3.50	0.00	1.954e+2	3.613e-1	1.285e-10	0.47	400.	6.409e-1	79594	9/9	Photometry | Synth.Spectrum
LOri014	Kurucz	4000	4.50	0.00	3.026e+1	2.257e-1	1.078e-10	0.49	400.	5.374e-1	79594	9/9	Photometry | Synth.Spectrum
LOri015	Kurucz	4000	3.50	0.00	6.432e+1	2.314e-1	1.122e-10	0.49	400.	5.596e-1	79594	9/9	Photometry | Synth.Spectrum
LOri016	Kurucz	3750	4.00	0.00	1.349e+2	2.743e-1	1.007e-10	0.48	400.	5.022e-1	45110	7/9	Photometry | Synth.Spectrum
LOri017	Kurucz	4250	3.50	0.00	5.090e+1	1.531e-1	9.220e-11	0.47	400.	4.598e-1	79594	9/9	Photometry | Synth.Spectrum
LOri018	Kurucz	3750	3.50	0.00	2.168e+2	2.738e-1	9.856e-11	0.47	400.	4.915e-1	79594	9/9	Photometry | Synth.Spectrum
LOri019	Kurucz	3750	3.50	0.00	8.971e+1	2.564e-1	9.332e-11	0.48	400.	4.654e-1	79594	9/9	Photometry | Synth.Spectrum
LOri020	NextGen	3500	4.5	0	1.557e+2	1.092e-20	9.436e-11	0.50	400.	4.705e-1	79594	9/9	Photometry | Synth.Spectrum
LOri021	Kurucz	3750	4.50	0.00	1.048e+2	2.130e-1	7.928e-11	0.49	400.	3.954e-1	79594	9/9	Photometry | Synth.Spectrum
LOri022	Kurucz	3750	4.00	0.00	6.562e+1	2.340e-1	8.561e-11	0.48	400.	4.269e-1	57593	8/9	Photometry | Synth.Spectrum

VOSA: SED analysis using theoretical models



VOSA: SED analysis using theoretical models

HR Diagram

Models

Plot | Mark All | Unmark All

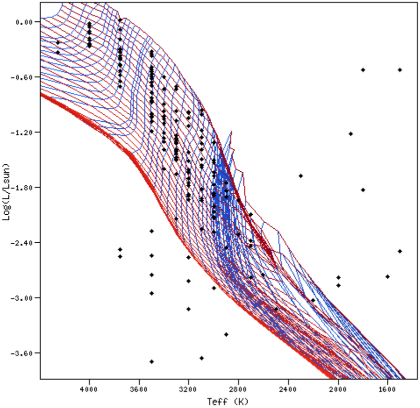
Plot	Model
☑	NextGen t:0.00100
☑	NextGen t:0.00125
☑	NextGen t:0.00158
☑	NextGen t:0.00199
☑	NextGen t:0.00251
☑	NextGen t:0.00316
☑	NextGen t:0.00398
☑	NextGen t:0.00501
☑	NextGen t:0.00630
☑	NextGen t:0.00794
☑	NextGen t:0.00999
☑	NextGen t:0.01258
☑	NextGen t:0.01584
☑	NextGen t:0.01995
☑	NextGen t:0.02511
☑	NextGen t:0.03162
☑	NextGen t:0.03981
☑	NextGen t:0.05011
☑	NextGen t:0.06309
☑	NextGen t:0.07943
☑	NextGen t:0.10000
☑	NextGen t:0.12589
☑	NextGen t:0.15848
☑	NextGen t:0.19952
☑	NextGen t:0.25118

Objects

Show | Show All | Show None

Show	Obj	Model	teff	logL	t	m
☑	LOri001	NextGen	4000	-0.0177	0.0030	1.1286
☑	LOri002	NextGen	3750	0.0145	0.0011 [1]	0.8990
☑	LOri003	NextGen	4000	-0.0539	0.0032	1.1059
☑	LOri004	NextGen	3750	-0.0838	0.0017	0.8617
☑	LOri005	NextGen	4000	-0.0349	0.0031	1.1172
☑	LOri006	NextGen	4000	-0.1075	0.0040	1.0993
☑	LOri007	NextGen	4000	-0.1778	0.0050	1.0469 [1]
☑	LOri008	NextGen	4000	-0.1202	0.0040	1.0977
☑	LOri009	NextGen	4000	-0.2374	0.0062	1.0500
☑	LOri010	NextGen	4250	-0.2329	0.0107	1.1506
☑	LOri011	NextGen	4000	-0.1286	0.0040	1.0962
☑	LOri012	NextGen	4000	-0.1998	0.0051	1.0569
☑	LOri013	NextGen	3750	-0.1932	0.0025	0.8476
☑	LOri014	NextGen	4000	-0.2697	0.0064	1.0474
☑	LOri015	NextGen	4000	-0.2521	0.0063	1.0495
☑	LOri016	NextGen	3750	-0.2991	0.0035	0.8178
☑	LOri017	NextGen	4250	-0.3374	0.0157 [1]	1.0536
☑	LOri018	NextGen	3750	-0.3085	0.0037	0.8153
☑	LOri019	NextGen	3750	-0.3322	0.0040	0.8102
☑	LOri020	NextGen	3500	-0.3274	0.0015	0.5389
☑	LOri021	NextGen	3750	-0.4030	0.0050	0.8011
☑	LOri022	NextGen	3750	-0.3697	0.0045	0.8044
☑	LOri023	NextGen	3750	-0.4097	0.0050	0.8007
☑	LOri024	NextGen	3750	-0.3870	0.0049	0.8023

X ∈ 1362.5 - 4394.375 Flip: ☑ Plot
Y ∈ -3.88647381 - 0.20951606 Flip: ☐



Building a VO server: S3wizard

- A wizard that helps you to build a VO service for a theoretical model.
  - Only needs the ascii files containing the data corresponding to each model.
  - and user inputs about the meaning of parameters, data columns, curation, credits...
  - All by a web interface.)
- The application builds:
  - The database
  - A web page with forms to download files in ascci and votable formats.
  - A VO service able to answer the three types of queries

THANK YOU!