VOSA

A VO Spectral Energy Distribution Analyzer

Carlos Rodrigo Blanco[1,2]
Amelia Bayo Arán[3]
Enrique Solano[1,2]
David Barrado y Navascués[1]

[1]CAB,INTA-CSIC
[2]Spanish Virtual Observatory
[3]European Southern Observatory

IVOA interoperability meeting
Victoria, May 17-21, 20010

VOSA (VO Sed Analyzer)

- a web tool: http://svo.cab.inta-csic.es/theory/vosa/
- designed to automatically determine physical parameters. of observed objects from comparison with collections of theoretical models.
- for several objects at the same time.
- Much easier using VO tools.

The case of the young cluster Collinder 69
(Bayo et al, 2008 A&A 429,277B)

- IRAC photometry for 167 candidate members of C69.
- VO archival data research (multi-wavelength range).
- Four 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)

Two different workflows

Theoretical model services   Documents   Models   **Services**

MINISTERIO DE CIENCIA E INNOVACIÓN

VOSA: VO Sed Analyzer

VO SED Analyzer

Services: **VOSA** **Filters** **TSAP** **S3if**   crb@laeff.inta.es **Users** **Models** **Uploads** **LogOut**

VOSA

VOSA allows to analyze both stellar and galactic data but, given that the physics involved is not the same, there are some important differences between both cases.

Please, select first what type of objects you want to work with in this session.

Stars and brown dwarfs

Galaxies

Workflow

1. Build objects SEDs.
   User photometry tables + VO catalogs.
2. Fit observed data with theoretical spectra models from the VO and estimate physical parameters for the objects. (Chi-square test)
3. Generate a Hertzsprung-Russel diagram using the estimated parameters and obtaining isochrones and evolutionary tracks from the VO (only stars).
4. Save results as VOTable, ASCII, png...

Using VO services.

- VO photometry catalogues *(ConeSearch)*.
- Theoretical spectra and syntetic photometry services *(SSAP/TSAP + S3)*.
- Isochrones and Evolutionary tracks services *(S3)*.

1. **User and VO photometry data.**
   - Upload user photometry data.
   - Query several photometry catalogs accessible through VO services.
   - Visualize and edit the final SEDs.
   - Manually specify the wavelength where infrared excess begins (only stars).

User data files

VOSA

Sessions | Files | Coordinates | VO Phot. | Objects | Model Fit | Template fit | HR Diag. | Save Results | Help | Logout

Stars and brown dwarfs **Session:** (info) (Change) **File: LOri** (info) (Change)

Upload your own data file (max size=500Kb)
It must comply with the required data format
Please, include a description for your file, it is **compulsory**

File to upload: Browse...
Description:
File type: Fluxes Magnitudes
Upload

Uploaded files

Select | Show | Retrieve | Delete

	Date	Filename	Descrip
◉	2010-05-14 11:32:02	LOri.dat	LOri

LOri001

Position: (83.446583,9.9273611) Distance: 400. pc A_V: 0.36209598

Filter:	CFHT_R	CFHT_I	2MASS_J	2MASS_H	2MASS_Ks	IRAC_I1	IRAC_I2	IRAC_I3	IRAC_I4
λ_{med}:	6582	8228	12350	16620	21590	35634	45110	57593	79594
Flux:	1.447193e-14	1.345174e-14	1.052144e-14	6.845070e-15	3.025102e-15	5.502778e-16	2.128458e-16	8.649135e-17	2.543987e-17
ΔF:	0.000000e+00	0.000000e+00	2.131932e-16	1.386999e-16	5.851066e-17	1.520474e-18	7.841528e-19	7.169533e-19	2.343098e-19

LOri002

Position: (84.043167,10.148583) Distance: 400. pc A_V: 0.36209598

Filter:	CFHT_R	CFHT_I	2MASS_J	2MASS_H	2MASS_Ks	IRAC_I1	IRAC_I2	IRAC_I3	IRAC_I4
λ_{med}:	6582	8228	12350	16620	21590	35634	45110	57593	79594
Flux:	1.170918e-14	1.204422e-14	1.119116e-14	8.745365e-15	4.129904e-15	7.207456e-16	2.589793e-16	1.123499e-16	3.434906e-17
ΔF:	0.000000e+00	0.000000e+00	2.473785e-16	1.852599e-16	7.227187e-17	1.991494e-18	7.155862e-19	9.313027e-19	2.530932e-19

LOri003

Position: (83.981000,9.9420833) Distance: 400. pc A_V: 0.36209598

Filter:	CFHT_R	CFHT_I	2MASS_J	2MASS_H	2MASS_Ks	IRAC_I1	IRAC_I2	IRAC_I3	IRAC_I4

VO photometry

VOSA

Sessions | Files | Coordinates | VO Phot. | Objects | Model Fit | Template fit | HR Diag. | Save Results | Help | Logout

Stars and brown dwarfs **Session:** (info) (Change) **File: LOri** (info) (Change)

VO photometry

This option allows you to increase the wavelength coverage of the SEDs of your objects adding photometry from VO catalogues.

Take a look to the corresponding Help Section and Credits Page for more information.

First select the VO services that you want to use

Mark All Unmark All

Query selected services

☑ **2MASS All-Sky Point Source Catalog**

2MASS has uniformly scanned the entire sky in three near-infrared bands to detect and characterize point sources brighter than about 1 mJy in each band, with signal-to-noise ratio (SNR) greater than 1. More Info.

Filters: ☑ 2MASS_J ☑ 2MASS_H ☑ 2MASS_Ks

Search radius: 5 arcsec

Show magnitude limits

☑ **Tycho-2 Catalogue**

The Tycho-2 Catalogue is an astrometric reference catalogue containing positions and proper motions as well as two-colour photometric data for the 2.5 million brightest stars in the sky.. More Info.

Filters: ☑ TYCHO_B ☑ TYCHO_V

Search radius: 5 arcsec

Show magnitude limits

☑ **CMC-14**

Visualize and edit the SED

VOSA

Sessions	Files	Coordinates	VO Phot.	Objects	Model Fit	Template fit	HR Diag.	Save Results	Help	Logout

Stars and brown dwarfs **Session:** (info) (Change) **File: LOri** (info) (Change)

Object data

- LOri001
- LOri002
- LOri003
- LOri004
- LOri005
- LOri006
- LOri007
- LOri008
- LOri009
- LOri010
- LOri011
- LOri012
- LOri013
- LOri014
- LOri015
- LOri016
- LOri017
- LOri018
- LOri019
- LOri020
- LOri021
- LOri022
- LOri023
- LOri024
- LOri025
- LOri026

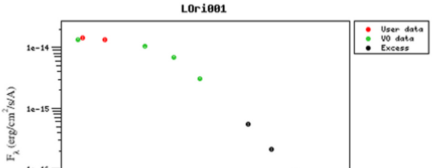
LOri001

Position: (83.446583,9.9273611) Distance: 400. pc A_V: 0.36209598

Data for this object:

		Final		User		VO		
Filter	λ_{med}	Flux	ΔF	Flux	ΔF	Flux	ΔF	
SDSS_R	6261	1.321348e-14	3.285918e-16	---	---	1.321348e-14	3.285918e-16	Delete
CFHT_R	6582	1.447193e-14	0.000000e+00	1.447193e-14	0.000000e+00	---	---	Delete
CFHT_I	8228	1.345174e-14	0.000000e+00	1.345174e-14	0.000000e+00	---	---	Delete
2MASS_J	12350	1.052144e-14	2.131932e-16	1.052144e-14	2.131932e-16	1.052144e-14	2.131932e-16	Delete
2MASS_H	16620	6.845070e-15	1.386999e-16	6.845070e-15	1.386999e-16	6.845070e-15	1.386999e-16	Delete
2MASS_Ks	21590	3.025102e-15	5.851066e-17	3.025102e-15	5.851066e-17	3.025102e-15	5.851066e-17	Delete
IRAC_I1	35634	5.502778e-16	1.520474e-18	5.502778e-16	1.520474e-18	---	---	Delete
IRAC_I2	45110	2.128458e-16	7.841528e-19	2.128458e-16	7.841528e-19	---	---	Delete
IRAC_I3	57593	8.649135e-17	7.169533e-19	8.649135e-17	7.169533e-19	---	---	Delete
IRAC_I4	79594	2.543987e-17	2.343098e-19	2.543987e-17	2.343098e-19	---	---	Delete

Excess detected from **IRAC_I1**. Points with larger wavelength will not be considered in model fit.
You can manually specify where excess starts.
Apply excess from IRAC_I1



Model Fit

2. **Fit observed data with theoretical models.**
    - Query VO-compliant theoretical models (spectra) and calculate their synthetic photometry.
    - Determine which model reproduces best the observed data.
    - Use the best-fit model to estimate, for each object:
        - $T_{\rm eff}$, Logg, metallicity (for stars).
        - Age, metallicity (for galaxies).
        - Bolometric luminosity, using the model as a correction to the observed data.

Model fit (galaxies)

VOSA

Coordinates	VO Phot.	Objects	Model Fit	Save Results	Help	Logout

Galaxies **Session:** (info) (Change) **File: test** (info) (Change)

Model fit

Choose the parameter ranges that you want to use for the fit

POPSTAR with Chabrier (2003) IMF

fluxtype:	--	(Flux type. Use star for star continuum, total for total flux)
logt:	5 - 10.18	(min)
z:	0.0001 - 0.05	(min)

POPSTAR with Ferrini, Penco, Palla (1990) IMF

fluxtype:	--	(Flux type. Use star for star continuum, total for total flux)
logt:	5 - 10.18	(min)
z:	0.0001 - 0.05	(min)

POPSTAR with Kroupa (2002) IMF

fluxtype:	--	(Flux type. Use star for star continuum, total for total flux)
logt:	5 - 10.18	(min)
z:	0.0001 - 0.05	(min)

POPSTAR using Salpeter (1955) IMF with m=(0.85-120)Msun

(Flux type. Use star for star continuum,

Model fit (galaxies)

VOSA

Coordinates	VO Phot.	Objects	Model Fit	Save Results	Help	Logout

Galaxies — **Session:** (info) (Change) — **File: test** (info) (Change)

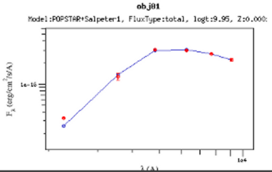
Model fit

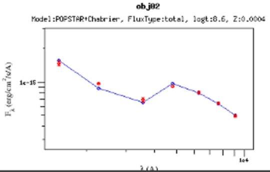
- Bestfit
- obj01
- obj02
- obj03
- obj04
- obj05
- obj06
- obj07
- obj08
- obj09
- obj10
- obj11
- obj12

Best fit results

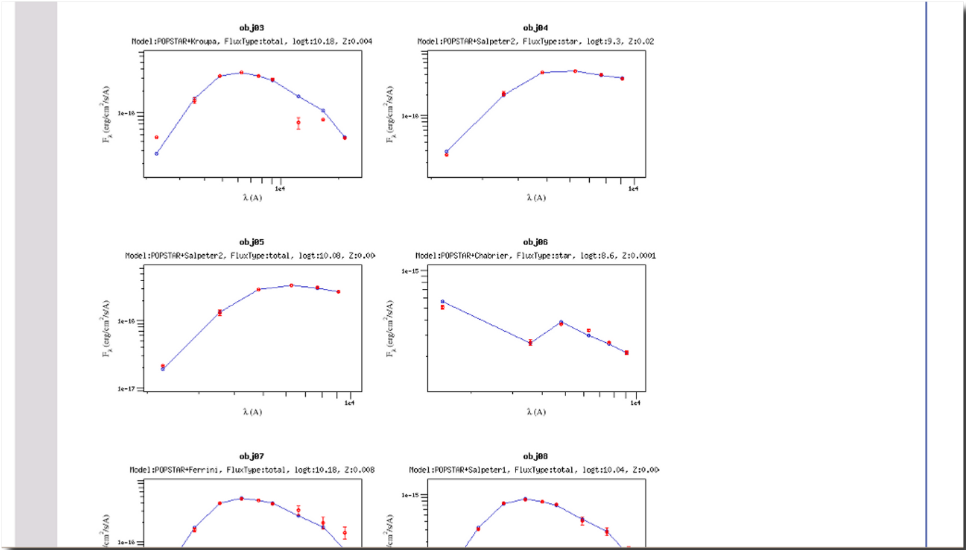
[Hide graphs] [Delete this fit]

Object	RA	DEC	D (pc)	Model	FluxType	logt	Z	χ^2	M_d	F_{tot}	ΔF_{tot}	F_{obs}/F_{tot}	L_{bol}/L_{sun}	$\Delta L_{bol}/L_{sun}$	Data VOtables
obj01	180.45623780	2.42146800	10.0	POPSTAR+Salpeter1	total	9.95	0.0001	4.43e+0	4.23e-12	3.12e-12	8.04e-15	0.14	9.72e-6	2.51e-8	Syn.Spec.
obj02	180.46192930	-0.65536590	10.0	POPSTAR+Chabrier	total	8.6	0.0004	1.49e+1	1.24e-12	9.86e-12	4.86e-14	0.18	3.07e-5	1.51e-7	Syn.Spec.
obj03	180.61964420	2.28855300	10.0	POPSTAR+Kroupa	total	10.18	0.004	1.27e+1	1.14e-11	3.67e-12	9.27e-14	0.26	1.15e-5	2.89e-7	Syn.Spec.
obj04	180.63633730	1.74878760	10.0	POPSTAR+Salpeter2	star	9.3	0.02	4.45e+0	6.67e-12	5.21e-12	6.61e-15	0.13	1.62e-5	2.06e-8	Syn.Spec.
obj05	180.96638490	1.83608130	10.0	POPSTAR+Salpeter2	total	10.08	0.004	1.08e+0	1.36e-11	3.70e-12	5.90e-15	0.13	1.15e-5	1.84e-8	Syn.Spec.
obj06	181.12615970	1.68400360	10.0	POPSTAR+Chabrier	star	8.6	0.0001	2.50e+1	4.54e-13	4.02e-12	9.69e-15	0.13	1.25e-5	3.02e-8	Syn.Spec.
obj07	181.14505000	1.84235870	10.0	POPSTAR+Ferrini	total	10.18	0.008	2.09e+0	1.79e-11	5.83e-12	2.74e-13	0.35	1.82e-5	8.55e-7	Syn.Spec.
obj08	181.19340520	2.00521780	10.0	POPSTAR+Salpeter1	total	10.04	0.004	1.79e+0	2.13e-11	9.65e-12	2.63e-13	0.31	3.01e-5	8.19e-7	Syn.Spec.
obj09	181.36636350	1.86136940	10.0	POPSTAR+Chabrier	total	8.9	0.0004	1.10e+1	6.85e-13	3.09e-12	3.21e-14	0.18	9.62e-6	1.00e-7	Syn.Spec.
obj10	186.59410100	-1.25504020	10.0	POPSTAR+Chabrier	star	7.7	0.02	6.68e+1	4.44e-13	1.13e-11	7.30e-14	0.21	3.51e-5	2.27e-7	Syn.Spec.
obj11	191.49058530	1.29803990	10.0	POPSTAR+Ferrini	total	8.3	0.0004	1.09e+1	4.95e-13	4.20e-12	1.33e-13	0.24	1.31e-5	4.15e-7	Syn.Spec.
obj12	192.91122440	1.67081900	10.0	POPSTAR+Kroupa	total	8.6	0.0004	4.16e+0	7.98e-13	5.72e-12	4.66e-14	0.18	1.78e-5	1.45e-7	Syn.Spec.





Model fit (galaxies)



3

Hertzsprung-Russel diagram.

- Use the Luminosity and T_{eff} estimated in the fit.
- Obtain isochrones and evolutionary tracks from the VO.
- Interpolate them to estimate values for the Mass and Age of each object.
- (only for stars and brown dwarfs).

HR diagram (stars)

VOSA

Sessions	Files	Coordinates	VO Phot.	Objects	Model Fit	Template fit	HR Diag.	Save Results	Help	Logout

Stars and brown dwarfs **Session:** (info) (Change) **File: LOri** (info) (Change)

HR Diagram

This option allows you to estimate values for the age and the mass of the objects. In order to do that, the (T_{eff},log(L)) values obtained from the fitting are used as starting points for interpolating collections of theoretical isochrones and evolutionary tracks obtained from the VO. Then, a HR diagram is displayed showing the data points, isochrones and evolutionary tracks.

Take a look to the corresponding Help Section and Credits Page for more information.

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: 0.00100 - 7.94328 (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: 0.020 - 1.400 (Min/Max value for the mass of the star. Masses are given in Msun)

HR diagram (stars)

VOSA

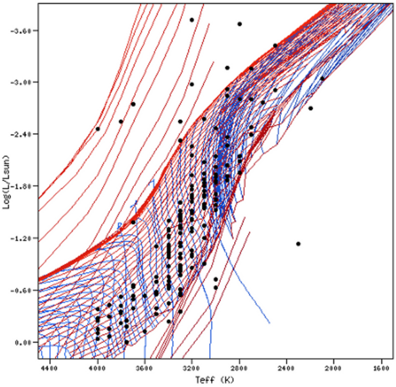
Sessions | Files | Coordinates | VO Phot. | Objects | Model Fit | Template fit | HR Diag. | Save Results | Help | Logout

Stars and brown dwarfs **Session:** (info) (Change) **File: LOri** (info) (Change)

HR Diagram

Objects

Object	Model	T_{eff}	LogL	Age		Mass	
LOri001	COND00	4000	-0.0297	---	[4]	---	[4]
LOri002	siess	3750	-0.0008	0.0010		0.4998	
LOri003	siess	4000	-0.1033	0.0019		0.7000	
LOri004	COND00	3600	-0.1223	---	[4]	---	[4]
LOri005	COND00	3900	-0.0638	---	[4]	---	[4]
LOri006	siess	4000	-0.1505	0.0020		0.7000	
LOri007	COND00	3800	-0.2146	---	[4]	---	[4]
LOri008	NextGen	3900	-0.1497	0.0037		1.0382	
LOri009	COND00	4000	-0.2490	---	[4]	---	[4]
LOri010	COND00	4000	-0.2713	---	[4]	---	[4]
LOri011	siess	3750	-0.1763	0.0010		0.4994	
LOri012	siess	3750	-0.2451	0.0012		0.4994	
LOri013	COND00	3400	-0.2337	---	[4]	---	[4]
LOri014	COND00	3900	-0.2919	---	[4]	---	[4]
LOri015	COND00	4000	-0.2673	---	[4]	---	[4]
LOri016	siess	3500	-0.3251	0.0010		0.3694	
LOri017	NextGen	4000	-0.3789	0.0097		1.0000	
LOri018	NextGen	3800	-0.3340	0.0049		0.8877	
LOri019	NextGen	3800	-0.3462	0.0050		0.8836	[1]
LOri020	COND00	3300	-0.3493	---	[4]	---	[4]
LOri021	DUSTY00	3800	-0.4148	---	[4]	---	[4]
LOri022	DUSTY00	3700	-0.3894	---	[4]	---	[4]
LOri023	NextGen	3800	-0.4205	0.0063		0.8505	
LOri024	COND00	3900	-0.4213	---	[4]	---	[4]
LOri025	NextGen	4000	-0.3813	0.0098		1.0000	
LOri026	NextGen	3500	-0.3870	0.0017		0.5090	
LOri027	COND00	3700	-0.4920	---	[4]	---	[4]
LOri028	COND00	3300	-0.5599	---	[4]	---	[4]
LOri029	NextGen	3400	-0.4406	0.0013		0.4271	
LOri030	NextGen	3800	-0.5177	0.0080		0.8177	
LOri031	COND00	3600	-0.5291	---	[4]	---	[4]

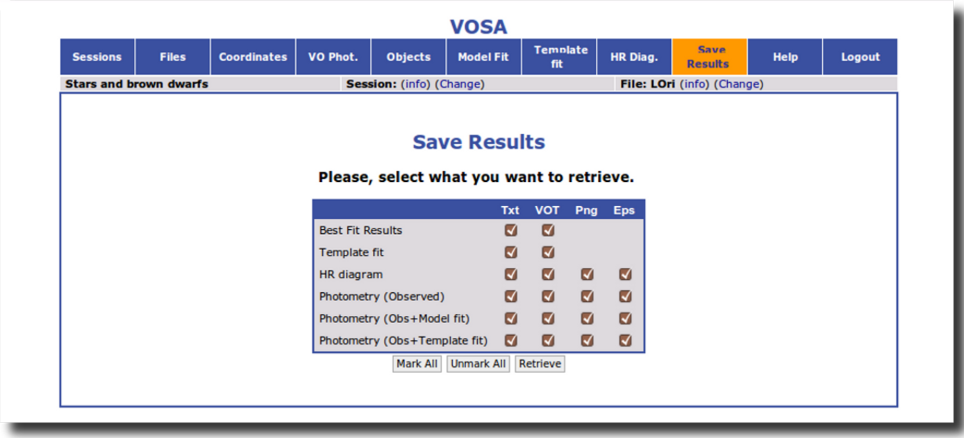


4

Save results.

- VOTable, ASCII
- PNG and EPS for the images available.
- Download as tar file.

Save results



Help and Documentation

VOSA help and documentation (Stars and brown dwarfs)

- Introduction
- Upload file format
- Filters
- Coordinates
- VO phot.
- Model Fit
- Template fit
- HR diag.
- Sessions
- Use Case
- Quality
- Credits
- Helpdesk
- About

Model Fit

[Introduction] [Fit] [Best Fit] [Reduced chi-square] [Excess] [Synthetic photometry] [Bolometric Luminosity]

Introduction

The main section of this application is the *Model fit*.

When the user clicks in the *Model fit* tab, a list of the files is shown. For each of them, a list of actions can be chosen:

- **Fit**. If the fit hasn't been done yet for this data file, this option starts the fit (and it is the only option that can be chosen). Otherwise, it shows the list of all the best fit results so that the user can choose the best one for each object (sometimes, there are reasons why the best physical fit is not the one with a smaller X^2_r and the user has the option to choose a different one as the best for a particular object).
- **Best Fit**. It only appears if the fit is finished. Here the user can see a table with the best fit for each object and, as an option, all the graphs for the best fits.
- **Del Fit**. If the user wants to start the fit process again (maybe with a different election of models or different ranges of parameters for some of them), it is necessary to delete the previous results first.

Fit

When a fitting process is started the user can choose among a list of theoretical spectra models available in the VO. Only those that are checked will be used for the fit.

In the next step the application uses the TSAP protocol (SSAP for theoretical spectra) for asking the model servers which parameters are available to perform a search. According to that, a form is built for each model so that the user can choose the ranges of parameters that he wants to use for the fit. Take into account that:

- The fitting process implies queries to VO services, data sent through the network, a lot of calculations (some done by the services themselves and some done by the application)... That means that it could take a long time to get the final results (seconds for only an object or half an hour for around 100 depending also on the load of the services).
- Using more models and wider ranges of parameters will imply a longer time for the fitting (specially if your file contains many objects) so be ready for a long waiting time in the next step.

THANK YOU!