Tutorials on Virtual Observatory tools

(based on the material presented during the 1st Asterics VO School
held in Madrid on Dec 15-17, 2015)

Determination of stellar physical parameters using VOSA:
The Collinder 69 open cluster

Scientific background: One of the most interesting star forming regions (SFR) is associated with the O8III star λ Orionis. The λ Orionis SFR includes several distinct associations, but for this work we will concentrate on the central cluster Collinder 69. Studying the physical parameters of a large population of sources belonging to the same cluster is advantageous, since we can infer properties not only of the individual sources but also of the association as a whole, for example its age, since we can assume that all objects are coeval.
The goal of this tutorial is to determine the physical parameters and properties (e.g. the effective temperature, gravity, age and mass) of a few candidate members of this cluster by comparing their Spectral Energy Distribution (SED) with theoretical models exploiting the capabilities of VOSA (Virtual Observatory SED Analyzer).

=== Getting started ===
* Step 1.- Go to http://svo2.cab.inta-csic.es/theory/vosa/
* Step 2.- To use VOSA you need to be registered. Click on "Register" and fill in the fields (email, name and password).
* Step 3.- Download the object list file in “VOSA format” in https://www.dropbox.com/s/gcth5u0ptf2isex/vosa_object_list.txt?dl=0

=== Tag “Files” ===
* Step 4.- Upload the file in VOSA (//"File to upload"//). Give a description (free text) and do not forget to select "magnitudes" as file type. Then, click "Upload". The message //"your-file-name" has been successfully uploaded!// will appear. Click "Continue".

=== Tag “Build SED —> VO Photometry” ===
* Step 5.- Skip the tag "Objects". With the next tag (“Build SED —> VO Photometry") we can complement our "user photometry" with photometry found in VO services. For this use case, click "unmark All" and select only 2MASS, WISE and APASS9 . Then, click "Query selected services" at the bottom of the page. Once this is done, a summary table with the VO photometry (in flux units) will appear.

=== Tag “Build SED —> SED edit/visualize” ===
* Step 6.- This tag gives us the possibility of visualizing/modifying the SED before the model fitting. Bad photometric points / upper limits can be deleted / not included in the fitting by clicking on the corresponding check box and click on "Apply changes". If VOSA detects an infrared excess, the photometric points are drawn in black and are not considered in the fitting process. The user can manually override it and specify a new limit in the "Excess" panel. Veiling can also be taking into account: Photometric points bluer than the wavelength included in the "Apply UV/ blue excess up to" box will not be included in the fit. For this use case, do not make any change.

=== Tag “Analyse SED —> Model Fit” ===

* Step 7.- In the next tag (“Analyse SED —> Model Fit”), different grids of theoretical models covering different ranges of physical parameters are displayed. For this case, click "Unmark All" and select only the "*BT-Settl-CIFIST*". To save time, do not tick either "Include model spectrum in fit plots?" or "Estimate fit parameter uncertainties using a statistical approach". Finally, click on “Next: Select model params".
* Step 8.- In this window, we can refine the range of physical parameters that will be used for the fit. We will make the following assumption:
    * Teff: 2000-5000K
    * logg: 3.5-5.0
    * meta=0.
    * Then, click on "Next: Make the fit".
* Step 9.- We can now see a summary table with the best fit results. Click on "Show graphs" to have a look at the graphics. The effective temperatures and logg obtained after the fitting are:
    * LOri0005: Teff: 3900K logg: 3.5
    * LOri0029: Teff: 3600K logg: 4.0
    * LOri0048: Teff: 3600K logg: 4.0
    * LOri0158: Teff: 3300K logg: 4.5

=== Tag “Analyse SED —> Model Bayes analysis” ===

* Step 10.- Alternatively, you can perform a Bayesian fitting using the "Analyse SED —> Model Bayes analysis" tag. To do so, we select the same collection of models and range of physical parameters as in Step9. Then, click "Make the fit". A summary table with information on the model with the highest probability is shown. For each object, the information is graphically displayed by clicking on the object name (top left panel).
* LOri0005: Teff: 3900K (99.97 %) logg: 3.5 (97.03 %)
* LOri0029: Teff: 3600K (37.85 %) logg: 4.0 (36.9 %)
* LOri0048: Teff: 3600K (44.44 %) logg: 4.0 (62.33 %)
* LOri0158: Teff: 3300K (80.24 %) logg: 4.5 (50.72 %)

=== Tag “HR Diag.” ===

* Step 11.- In order to estimate ages and masses for our objects we will make use of the "HR Diag." tab. Click on "Make the HR diagram". Ages derived for LOri0005, LOri0029 and LOri0048 are consistent with the age of the cluster (upper limit: 12-16 My).

=== Tag “Results —> Download results” ===

* Step 12.- You can save different type of results (plots, VO photometry, Bayes fit, chi-2 fit, ...) using the "Results —> Download results" tag.

=== Tag “Results —> Activity Log” ===

* Step 13.- A summary of all steps executed to carry out the workflow can be found in the "Results —> Activity Log" tag.

=== Tag "Help" ===

* Step 14.- A detailed description of how VOSA works can be found in the "Help" tag.

References:

Bayo et al., 2008 A&A 492, 277

Discovery of Brown Dwarfs mining the 2MASS and SDSS databases with ALADIN

Scientific background: Brown dwarfs are objects occupying the gap between the least massive stars and the most massive planets. They are intrinsically faint objects so their detection is not straightforward and, in fact, was almost impossible until the advent of global surveys at deep optical and near-infrared bands like SDSS, 2MASS or DENIS among others. We propose here to mine the 2MASS-PSC and SDSS-DR9 databases to identify T-type brown dwarfs through an appropriate combination of colors in the optical and the infrared, an approach that perfectly fits into the Virtual Observatory.

* Launch Aladin: Open a terminal and type: “java -Xmx2048m -jar AladinBeta.jar &” or open the Aladin application - You can download the Aladin Desktop application from here: http://aladin.u-strasbg.fr/java/nph-aladin.pl?frame=downloading

* Search 2MASS-PSC and SDSS-DR9 sources around RA: 08h 30m DEC: 01d 30m with a 14 arcmin radius.
  * File --> Open --> Surveys
  * Write 08:30:00 01:30:00 in the "Target" box
  * Click on the 2MASS-PSC catalogue. "2MASS-PSC" will appear in the "Survey" box.
  * Click on "Submit". Aladin will load the 2MASS-PSC plane with 683 sources.
  * Repeat the same steps for the SDSS-DR9 catalogue. A new plane will be loaded with 12404 sources.

* Find common sources in 2MASS-PSC and SDSS-DR9 catalogues.
  * Catalog --> Cross match objects (or click on the "Cross" button on the right panel of Aladin main window).
  * First catalogue: 2MASS-PSC. Second catalogue: SDSS-DR9.
  * Default threshold (4 arcsec) and “bestmatch" option
  * Click on "Perform cross-match". A new plane ("X-match") with 679 sources will be loaded.

* Select points sources using the SDSS flag (cl=6)
  * Hide (cursor on the name of the plane and then click mouse right button) the 2MASS-PSC and the SDSS-DR9 planes
  * Click on the "Xmatch" plane
  * Catalogue --> Create a filter (or click on the "Filter" button on the right panel of Aladin main window).
  * Advanced mode --> Columns --> Columns in loaded catalogue. Select the "cl_tab2" column from the Xmatch catalogue
  * Complete the filter condition. It should be ${cl_tab2}=6 {draw}
  * Click on "Apply". Then click on "Export" to create a new plane with the filtered sources.
  * A new plane "Filter.src" will be loaded in the Aladin main window. It contains 649 sources.

* Select sources with no detection in the u,g SDSS filters (u > 22.0 && g > 22.2). Brown dwarfs are cool objects so they are not detected in the blue SDSS filter.

  * Hide the Xmatch plane
  * Click on the "Filter.src" plane
  * Repeat the same steps as in the previous filter. The filter condition should be:
    ${umag_tab2}>22.0 && ${gmag_tab2}>22.2 {draw}
  * A new plane "Filter.src-1" will be loaded in the Aladin main window. It contains 6 sources.

* Select sources following the brown dwarf criteria provided by
  Burgasser et al. (2000, Apj, 531, L57): (J-H)<0.3 && (H-K)<0.3
  * Hide the Filter.src plane
  * Click on the "Filter.src-1" plane
  * Now you can either use arithmetic operations between columns directly in the filter syntax, or you can create new columns (Catalog --> Add a new column) that are an arithmetic combination of 2 columns (e.g. Jmag - Hmag)
  * The filter condition should be:
    ${Jmag_tab1}-${Hmag_tab1}<0.3 && ${Hmag_tab1}-${Kmag_tab1}<0.3 {draw}
  * A new plane "Filter.src-2" will be loaded in the Aladin main window. It contains 1 source. (RA: 127.703265 deg; DEC: 1.475320 deg).

* We can now use Simbad to confirm the brown dwarf nature of this object
  * File --> Open --> Simbad
  * Click on "Grab coord" and click on the source. The coordinates of the source will be copied to the "Target (ICRS, Name)" box.
  * Select a 30 arcsec radius. Click "Submit"
  * A new plane "Simbad" will be loaded in the Aladin main window.
  * Click on the "Simbad" plane. Select all sources in this plane (mouse right button). A table containing one row will appear at the bottom of the Aladin main window.
  * Click on the Main ID. Simbad will be launched in your browser with information on the source.

References:

Burgasser et al. (2000, Apj, 531, L57)