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COOL OBJECTS: FROM SED FITTING TO AGE ESTIMATION

A. Bayo[1,2], D. Barrado y Navascués[1,2], M. Morales–Calderón[1], E. Solano[1,2], C. Rodrigo[1,2], R. Gutiérrez[1,2], and F. Allard[3]

[1]Laboratorio de Astrofísica Espacial y Física Fundamental (LAEFF-INTA), P.O. 50727, E-28080 Madrid, Spain
[2]SVO Thematic Network, Spain
[3]Centre de Recherche Astronomique de Lyon (CRAL), Ecole Normale Supérieure de Lyon, 69364, Lyon, France

ABSTRACT

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. This process usually involves working with multiwavelength data, which is one of the cornerstones of the VO philosophy. From this kind of studies, when combining with theoretical isochrones one can even estimate ages. We present here the results obtained from a code designed to perform χ^2 tests to both spectroscopic models (or the associated synthetic photometry) and combinations of blackbodies (including modified blackbodies). Some steps in this process can already be done in a VO environment, and the rest are in the process of development. We must note that this kind of studies in star forming regions, clusters, etc. produce a huge amount of data, very tedious to analyze using the traditional methodology. This make them excellent examples where to apply the VO capabilities.

Key words: Cool objects; Age estimation; Virtual Observatory.

1. INTRODUCTION

The determination of physical parameters of astronomical objects from observational data is usually linked with the use of theoretical models as templates. It is very common to estimate gravities of stellar objects by fitting different model/templates to gravity–sensitive lines present in observed spectra. Another usual method is to compare slopes in Spectral Energy Distributions constructed from observational photometric data with synthetic ones derived using theoretical spectra.
These commonly used methods easily turn to be tedious when being applied to large amount of data. Nowadays, astronomers deal with very large databases, not only consisting in observational data but also models from different groups that need to be combined in order to improve the results.
The Virtual Observatory seems to be one of the possible solutions to some intrinsic problems that this new way of doing astronomy generates. VO-tools[1] now allow astronomers to deal with their own observational or theoretical databases and compare them with others already published in the "on-line literature".
However, the Virtual Observatory is still under development, and there are some very useful and common tasks, in particular in the field of spectroscopy, that could be implemented in the near future.

2. THE SCIENTIFIC CASE

Our group is involved in a comprehensive study of the Lambda Orionis Star Forming Region. This region includes several distinct associations: Collinder 69, Barnard 30 and 35, as well as other dark clouds, LDN 1588 and 1603. We use as an example in this work Collinder 69. Although we have collected multiwavelength photometric data from the optical to the mid-infrared regime in this association, in this work we have only used IRAC (the mid-infrared camera on-board the Spitzer Space Telescope) photometry (Barrado y Navascues et al., 2007). Therefore, the original data consists of four photometric points (when detected) per object of the sample.

Our goals are the following:
1.- Build the Spectral Energy Distributions for every object in our sample using the photometric data available in astronomical archives and services (a typical VO task).
2.- Obtain theoretical synthetic spectra corresponding to the regime of physical parameters of interest (models form the Lyon group Allard et al. 2001).
3.- Compute the synthetic photometry from the theoretical models and the appropriate filter systems (mainly DENIS Consortium Denis 2005, 2MASS Skrutskie et al. 2006 and Spitzer/IRAC).

[1]`http://ivoa.net/twiki/bin/IVOA/IvoaApplications`

4.- Perform independent statistical tests to determine the best fitting model, and the best combination of blackbody + modified blackbody (for those objects possibly harboring a disk) for each target. With these fittings we can estimate different parameters: $T_{\rm eff}$ and gravity when fitting theoretical models, and an estimation of the distribution of temperatures of the disk when fitting a modified blackbody.
5.- Compare the physical parameters obtained with theoretical isochrones and evolutionary tracks in order to have an age and mass estimation per each target of the sample, and an age estimation for the sample as a whole.

3. THE METHOD

We have followed the steps stated in the previous section trying to use only VO-compliant tools during the process. We have found that one of the items (number four) cannot be made in the VO-environment since there is no tool that fulfill our requirements. Thus we have developed IDL and PERL codes to complete this step.
We also find problems in step number two since not all the filter transmission curves were available in the VO Filter Profile Service[2]. In those cases (DENIS and IRAC) we had to query directly the web pages of the respective consortia. Another point was that there is no VO-tool that performs the composition filter + model = synthetic photometry (taking into account the rebinning and normalization issues).

3.1. Virtual Observatory Tools

Following the scheme of section 2, we started by visualizing our data with TOPCAT, and "sending" this VOTable to Aladin to query some photometric catalogues (mainly DENIS and 2MASS) looking for counterparts in a given radius.
We performed a parallel query with VOSED[3] to look for spectroscopic observations of any of our sources available through the different data servers. The result of this query was that there was not available data.
At this point we were able to visualize the constructed SEDs with different tools such as VOSpec[4], SPECVIEW[5] and SPLAT[6].
The next step was to download the theoretical spectra to be used in our fitting process. They are accessible in a VO-environment from the Spanish Virtual Observatory Theoretical Model Web Server: http://laeff.inta.es/svo/theory/db2vo/html/
Once we had the grid of models, we extracted the synthetic photometry with our codes and performed χ^2 test to determine the best fitting model (and combination of blackbody + modified blackbody for the objects harboring a disk). This kind of fittings provide us with estimations of $T_{\rm eff}$ and gravity that we can use to compare with theoretical isochrones and evolutionary tracks (available at: http://laeff.inta.es/svo/theory/draw/getiso.php?inises=guest) and thus to estimate ages and masses.

[2] http://voservices.net/filter/filterlist.aspx?mode=keyword&keyword=
[3] http://sdc.laeff.inta.es/vosed/
[4] http://esavo.esa.int/vospec
[5] http://www.stsci.edu/resources/software_hardware/specview/users
[6] http://www.starlink.ac.uk/splat

4. CONCLUSIONS

We have estimated different physical parameters ($T_{\rm eff}$, gravity, mass, age, radius and distance) for 170 candidate members of Collinder 69. To achieve these estimations, we have made use of some of the Virtual Observatory capabilities (such as queries to different databases, including transmission curve filters, catalogues cross-matches, arithmetical operations on different columns from catalogues, etc.)

In the process of this work we have identified some tasks that are performed in a non VO-compliant environment. We think the implementation of these tasks in VO tools could be one of the next steps in the development of the Virtual Observatory, since these are very commonly used tasks that involve interoperability and other VO main bases.

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