SPECTRUM INTERPOLATOR FOR THE ELODIE LIBRARY

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ABSTRACT

We present a service, registered in the Virtual Observatory, to produce spectra at any desired effective temperature, surface gravity and metallicity using a library of spectra observed with the ELODIE spectrograph.

This interpolator is noticeably used to generate grids for stellar population synthesis with the PEGASE.HR code (Le Borgne et al. (2004)). It can also be used to determine the atmospheric parameters of stars.

Key words: Virtual Observatory.

1. STELLAR LIBRARIES & POPULATION SYNTHESIS

To study the stellar population of galaxies one compares observed spectra to models. These models, meant to represent the real stellar populations, consist of linear combinations of stellar spectra accounting for the importance of each class of stars for the considered age, metallicity and other characteristics of the considered population. The essential steps of population synthesis are:

1. Assemble a library of stellar spectra covering all the desired range of atmospheric parameters. It can be either from observed spectra of from modeled spectra. Until now the synthetic atmospheres are not good enough to match real observations, but their quality improves and some fundamental reasons require that they will become prominent in the future. Present important observed libraries are ELODIE (Prugniel & Soubiran, 2001; Prugniel et al., 2007), CFLIB (Indo-US; Valdes et al. (2004)) and Miles (Sanchez-Blazquez et al., 2006). The best theoretical libraries are Coelho et al. (2005) and Munari et al. (2005).

2. Interpolate the spectra over this library in order to produce spectra at the node of a grid used by the synthesis program.

3. Use a synthesis program which determines from stellar evolution models (evolutionary tracks), Initial Mass function, Star formation and metal enhancement history how to combine the stellar spectra. An example of synthesis program is PEGASE.HR (Le Borgne et al., 2004), which is available as a service of the VO (see in VOSpec, or search the registries). Other examples are GALAXEV (Bruzual & Charlot, 2003) and Vazdekis/Miles (In preparation[1]).

2. INTERPOLATING THE SPECTRA

For population synthesis, we need to generate spectra at any point of a 3D grid in temperature, surface gravity and metallicity. Different methods exist: pick the nearest neighbor, apply a Gaussian kernel smoothing or use piecewise polynomials. The first two methods generate biases linked to the distribution of the observed stars in the parameters space.

For example, to generate a model at sub- or super-solar metallicity, GALAXEV chooses the stars having the closest metallicity in the library. But, since this library of only 200 stars has a distribution strongly peaked at solar metallicity, the nearest stars are systematically in average closer to solar than the targeted metallicity (Fig. 1).

The last method generates also systematics due to the usage of a non-physical parametric representation of the spectra, but with the new large libraries they are limited to acceptable levels. This method produces an interpolator, which is a smooth function of temperature, metallicity and gravity:

$$\text{S}(\lambda) = \text{Interpolator}(T_{eff}, \log g, \text{[Fe/H]}, \lambda) \quad (1)$$

[1]http://www.ucm.es/info/Astrof/miles/models/models.html

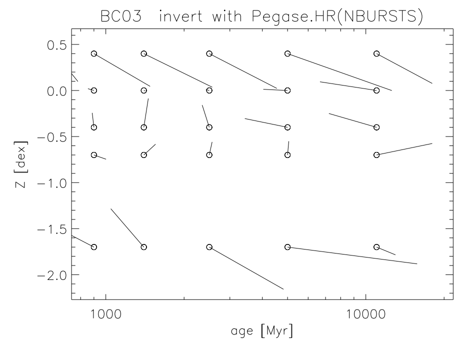

Figure 1. Inversion of GALAXEV (BC03) with Pegase-HR models. Each vector represents an individual inversion. The dot points the location of the nominal characteristics of the population and the end of the vector the characteristics returned by the analysis procedure. This illustrate the importance of the interpolator: The BC03 usage of a small stellar library of mostly stars of solar metallicity, produces strong biases of the models toward solar metallicity.

Where S is the resulting interpolated spectrum.

Comparisons made between different models using these different methods show an acceptable consistency (Koleva et al., 2007), but direct comparisons between the interpolators are not possible because their codes is not publicly available.

The interpolator over a grid of observed spectra has other applications than population synthesis, noticeably stellar classification and determination of atmospheric parameters: A non-linear fit of an observed spectrum against Interpolator$(T_{eff}, \log g, [Fe/H], \lambda)$ leads to a determination of T_{eff}, $\log g$ and [Fe/H].

3. DESCRIPTION OF THE SERVICE

There are two reasons to provide the interpolator as a separate service in the VO. (1) It opens the possibility to test the individual ingredients of the population synthesis, and (2) it has other applications like the determination of atmospheric parameters or creation of mock observations to assist instruments design.

The present service is the on-line version of the interpolator described in Le Borgne et al. (2004) and used for PEGASE.HR. It is based on piecewise polynomials in temperature, gravity and metallicity, somehow similar to the classical fitting functions used for Lick indices. In the future, we will also provide the interpolators for the updated version of the ELODIE library as well as for the other empirical and theoretical libraries.

The service is registered in the VO as a SSA (or Theoretical Spectrum Access), and can be used through VOSpec. The access to such modeling services through the Virtual Observatory offers several advantages:

- Codes requiring voluminous external resources, intensive computations or complex installation may advantageously be used as a remote service.
- Standardization of access methods and of output data-models and format is an important contribution toward the modularity of complex procedures.
- Some individual tasks involved in a specific complex procedure may be relevant to other applications, as the present interpolator can be used for stellar physics. The VO provides an appropriate framework for distributing these atomic services.

The present SSA IVOA standard is not sufficient to implement this service. We used the definition of the `FORMAT=METADATA` request introduced by P. Osuna in the VOSpec client. The service is not entirely based on standards and is therefore a prototype.

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