The Spectral Energy Distribution of Galaxies
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A first glance into the Spectral Energy Distributions of Single Stellar Populations in the Infrared range

Sofia Meneses-Goytia and Reynier F. Peletier

Kapteyn Instituut, Rijksuniversiteit Groningen,
Landleven 12, 9747AD, Groningen, the Netherlands

email: s.meneses-goytia@astro.rug.nl

Abstract. The present work shows the Spectral Energy Distributions (SEDs) in the infrared using the IRTF stellar library, obtained using models based on Single Stellar population Models (SSP). We have focused on the K band in order to compare with observables of elliptical galaxies. We also present the comparisons of our models with velocity dispersions, ages and metallicities obtained with models in the optical range.

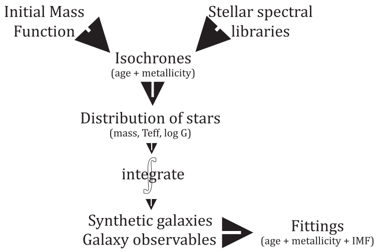
Keywords. infrared: stars, galaxies, galaxies: formation, elliptical

1. Introduction

Light is what we can actually obtain from an object and, therefore, its spectrum is one of the most important, or even the only way to gather any information about it. The spectra of individual stars can provide an idea of the behaviour of a larger object, whether they are part of it (resolved) or not (unresolved). We use unresolved Single Stellar Population (SSP) synthesis models to interpret the light of faraway galaxies. These models are based on the assumption of a single burst of stars that share the same characteristics, such as age and/or metallicity (e.g. Vazdekis *et al.* 1996). A Spectral Energy Distribution (SED) is the spectrum of a SSP model, which allows us to study the theoretical spectra as a whole, compared to an observed object (Yamada *et al.* 2008, Vazdekis *et al.* 2010). Therefore, we have to adapt the synthetic spectra to the characteristics of observed objects, in this work, elliptical galaxies, by convolving it to the observed resolution and velocity dispersion. With that, we can compare to the full spectrum allowing us to have insights into ages, metallicities, Initial Mass Functions (IMF), etc. The aim of working in the IR range is to relate this approach to early-type galaxies, since most stars in these galaxies are old (RGB) and therefore emit most of their light in the IR (Maraston 2005).

2. SSP synthesis models and fittings

The basic scheme of SSP modelling is shown in Fig. 1, based on Tinsley 1980. Using a given set of isochrones (at a certain age and metallicity), and an assumed Initial Mass Function (IMF), we interpolate the evolutionary tracks with a given stellar library in order to obtain a distribution of theoretical stars. When integrating the light of these stars, we obtain a synthetic spectrum of a galaxy with a particular set of parameters (i.e. age and metallicity). The last step is then to compare this set of spectra to observations. For this first glance, we use the Marigo *et al.* (2008) isochrones, which have a wide range of metallicities and ages. In addition, they provide the stellar flux in several bands, including in the IR. For the IMF we adopt KTG universal. As the input library, we chose the IRTF stellar library (Rayner *et al.* 2009, Cushing *et al.* 2005) for which we homogenized the stellar parameters (Teff, log G and metallicity) through a full spectrum fitting approach and interpolation, with aid of M. Koleva (IAC-Spain and University of Ghent-Belgium). For more details of the chosen ingredients of our models, see Fig. 1.



Ingredient	Name	Characteristics
IMF	KTG	Universal
Stellar library	IRTF	R ≈ 2000 292 stars 0.8 to 2.5 μm or 5.2 μm
Isochrones	Marigo	$-2.27 \leqslant [Z/Z_\odot] \leqslant 0.2$ ages up to 15.85 Gy magnitudes in IR bands

Figure 1. Basic outline and ingredients for SSP modeling in this work.

We based our approach on the Vazdekis *et al.* SSP models (Vazdekis *et al.* 1996, 1997, 2003 and 2010, Vazdekis 1999), that have been proven to work in the optical range using the CaT (Cenarro *et al.* 2001) and MILES stellar libraries (Sanchez-Blazquez *et al.* 2006). These models have also provided the spectra of these populations, i.e. the SEDs (Yamada *et al.* 2008, Vazdekis *et al.* 2003, hereafter V03 and 2010).

Here we focus on the K band, to compare with properties of observed elliptical galaxies from Marmol-Queralto *et al.* (2009, here after MQ09) selected in K band (2.19 to 2.34 μm), of which 12 are field galaxies and two more belong to Fornax. For the comparison, we use the maximum penalized likelihood approach, from Cappellari and Emsellen (2004) used in the programming package pPXF. This routine convolves the theoretical models to match the resolution and velocity dispersion of the observations and then compares them pixel by pixel to obtain the best fit.

3. Results

In Fig. 2, we show three of our models (with normalized flux) at solar metallicity, in J, H and K bands (from 0.93 to 2.41 μm). Furthermore, Fig. 3 shows fits to two observed galaxies, along with resulting age, metallicity and best fitting model as obtain using the pPXF method. The figure shows that the model (red line) provides a good representation of the observed data (black line), as can be seen by looking at the residuals (green dots). Additionally, through the fits using pPXF we were also able to obtain the kinematics of the studied galaxies, which can be compared to the ones published by MQ09 and the HyperLeda database, as shown in Fig. 4.

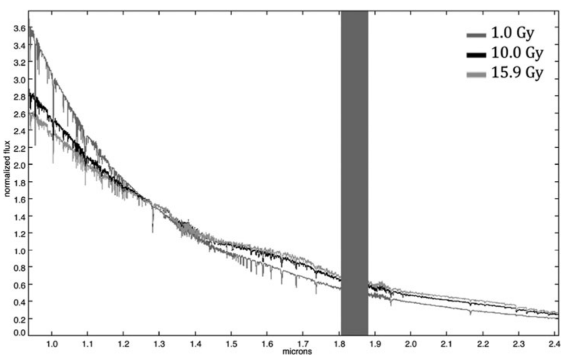


Figure 2. SSP models for a galaxy with solar metallicity at three ages

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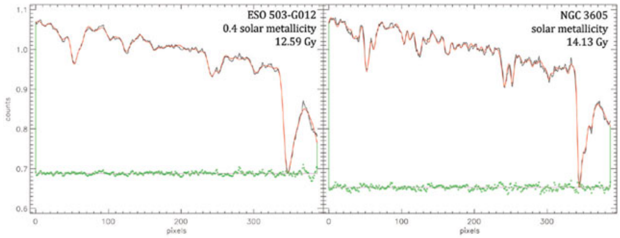

Figure 3. Comparison of the SSP models with two observed elliptical galaxies

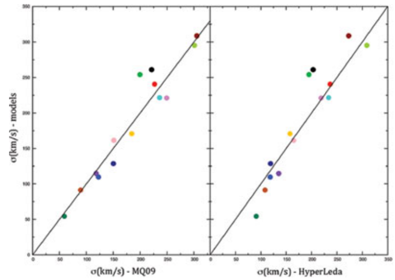

Figure 4. Comparison of the velocity dispersion obtained with models fittings and published

4. Conclusions and future work

To obtain the real accuracy of our models, some tests are being done using the IRTF stellar library and the models. Among these tests are calculating the Full Width at Half Maximum (FWHM) in collaboration with J. Falcon-Barroso (IAC-Spain); obtaining the integrated colours, (J-H), (J-K) and (H-K); and calculating the indices. Furthermore, we also need to understand the behaviour of the spectra in certain regions of the spectrum, and what is lost from the stars when they are integrated into the synthetic galaxy, etc. A future application for these models will be for the X-Shooter IR range.

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References

Cappellari, M. & Emsellem, E. 2008, *PASP*, 116, 138
Cenarro, A. J., Gorgas, J., Cardiel, N., Pedraz, S., Vazdekis, A., & Peletier, R. F. 2001, *ApSSS*, 277, 319
Cushing, M. C., Rayner, J. T., & Vacca, W. D. 2005, *ApJ*, 623, 1115
Maraston, C. 2005, *MNRAS*, 362, 779
Marigo, P., Girardi, L., Bressan, A., Groenewegen, M. A. T.., Silva, L., & Granato, G. L. 2008, *A&A*, 482, 883
Marmol-Queralto, E., Cardiel, N., Sanchez-Blazquez, *et al.* 2009, *ApJ*, 705, 199
Rayner, J. T., Cushing, M. C., & Vacca, W. D. 2009, *ApJS*, 185, 289
Sanchez-Blazquez, P., Gorgas, J., Cardiel, N., & Gonzlez, J. J. 2006, *A&A*, 457, 809
Thomas D., Maraston C., & Bender R. 2003, *MNRAS*, 339, 897
Tinsley B. M. 2003, *FCPh*, 5, 287
Vazdekis, A., Casuso, E., Peletier, R. F., & Beckman, J. E. 1996, *ApJ*, 106, 307
Vazdekis, A., Peletier, R. F., & Beckman, J. E. 1996, *ApJ*, 106, 307
Vazdekis, A. 1999, *ApJ*, 111, 203
Vazdekis, A., Cenarro, A. J., Gorgas, J., Cardiel, N., & Peletier, R. F. 2003, *MNRAS*, 340, 1317
Vazdekis, A., Sánchez-Blázquez, P., Falcón-Barroso, J., *et al.* 2010, *MNRAS*, 26, 147
Yamada, Y., Arimoto, N., Vazdekis, A., & Peletier, R. F. 2008, *ApJ*, 674, 612