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Synthesis of composite stellar populations models

Jean Michel Gomes[1,2], R. Cid Fernandes[1] & D. Valls-Gabaud[2]

[1]Dpto. de Física - CFM - Universidade Federal de Santa Catarina, Florianópolis, SC, Brazil
[2]GEPI, Observatoire de Paris, CNRS, Université Paris Diderot; Place Jules Janssen 92190 Meudon, France

Abstract. Spectral synthesis is largely used in the literature to decompose stellar populations with integrated light of galaxies as if the star formation histories (SFH) could be approximated by single bursts. In the case of our method (see http://www.starlight.ufsc.br/ for the SEAGal - Semi Empirical Analysis of Galaxies - collaboration), the STARLIGHT code combines the spectra of simple stellar populations (SSP) of different ages and metallicities, computed with high spectral resolution evolutionary synthesis models of Bruzual & Charlot (2003), to reproduce the observed spectrum of a given galaxy from which we can derived a huge amount of galaxy properties such as: the population vector, stellar mass, extinction and others. We have done that for all galaxies of the SDSS database. Despite all the results of astrophysical interest, we have decided to use continuous composite stellar models (CSP) with a single metallicity and a star formation rate $\propto \tau^{-1}e^{-t/\tau}$, where t stands for the time that the star formation started (1, 5 and 13 Gyr ago) and τ is the attenuation factor chosen to be 1, 5, 10 and 99 Gyr. When the attenuation with respect to the time t is very low, this mimics a single burst, and when we choose it to be very large (99 Gyr), this is almost a constant star formation rate. We have perturbed each composite model spectrum 10 times with three distinct signal/noise ratios equal to 10, 15 and 30 in $\lambda_0 = 4020$ Å. These models were inserted into our code to verify how a picture of single bursts deal with continuous composite models of galaxies. Our CSP models can be easily integrated in an analytical form. Therefore, we have derived theoretically the mean ages and metallicities and compared them to the output derived by the synthesis. We can see that the synthesized mean ages weighted by light tend to be lower than the models, due to the degeneracies involved in the problem. The same thing can be found for the mean metallicities weighted by light, which tend to be higher for the output values.

Keywords. galaxies: evolution, galaxies: synthesis models, galaxies: stellar content.

1. Introduction

The main objective is to analyze how properties of galaxies are recovered by our synthesis code STARLIGHT when we generate fictitious composite stellar population galaxies. We have used single metallicity ($Z_\star = 0.005, 0.02, 0.2, 0.4, 1, 2.5\ Z_\odot$) models of Bruzual & Charlot 2003 (BC03) with a star formation rate equal to:

$$\psi(t) \propto \tau^{-1}e^{-t/\tau} \tag{1.1}$$

where, $t = 1, 5, 13$ Gyr and $\tau = 1, 5, 10$ and 99 Gyr. Each test galaxy was perturbed 10 times with a S/N equal to 10, 15 and 30 in $\lambda_0 = 4020$ Å. These galaxies were synthesized using BC03, as if the star formation histories are discrete (represented by single bursts).

2. Results

The mean stellar ages ($\langle \log t_\star \rangle_L$) and metallicities ($\log \langle Z_\star \rangle_L$) from the models (in) are compared with the results of the STARLIGHT (out), see Cid Fernandes *et al.* (2005)

for a full revision. We can see that models with low metallicities can have errors of 0.5 dex in the mean ages and 1 dex in the mean metallicities, which are extremely high. However, if we eliminate these models we can see that the errors are about 0.2 dex in mean ages and metallicities, but the ages are systematically lower and the metallicities higher. Therefore, the code prefers SSP younger and more metallic to adjust composite models.

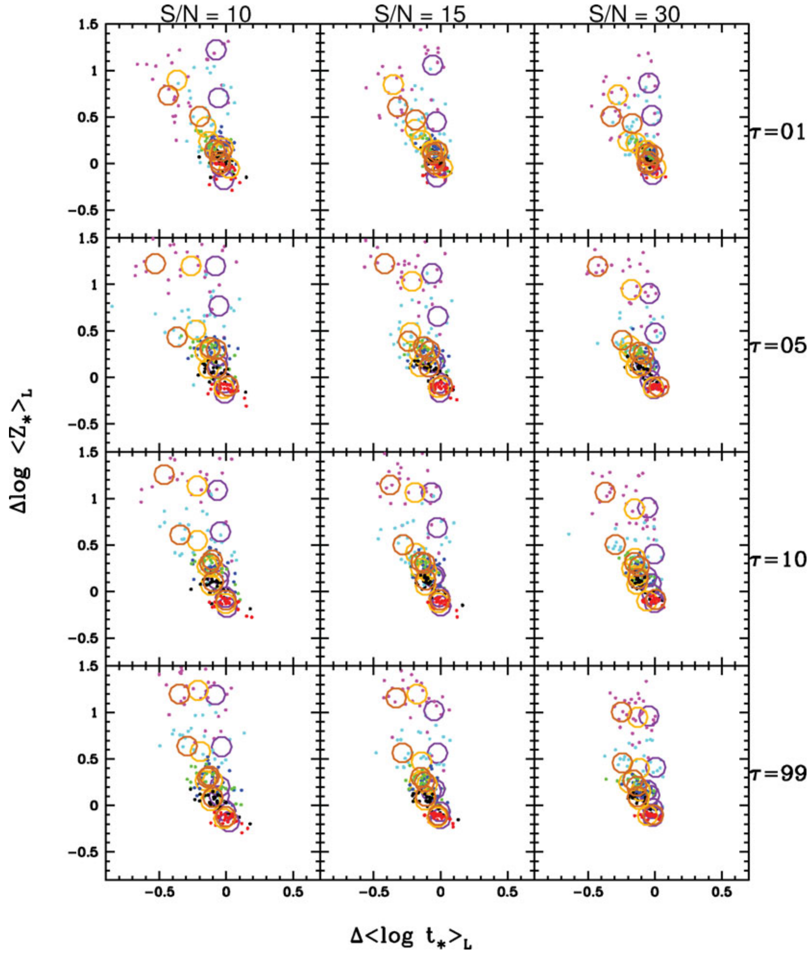

Figure 1. Age versus metallicity degeneracy for composite stellar population models. $\Delta \log\langle Z_\star\rangle_L = \log\langle Z_\star\rangle_L^{out}$ - $\log\langle Z_\star\rangle_L^{in}$ and $\Delta\langle\log t_\star\rangle_L = \langle\log t_\star\rangle_L^{out}$ - $\langle\log t_\star\rangle_L^{in}$. The colors of the dots are for different metallicity models: 0.005 (magenta), 0.02 (cyan), 0.2 (blue), 0.4 (green), 1 (black) e 2.5 (red) $Z_\odot$. We show the results for distinct S/N = 10, 15 e 30 from left to right. The attenuation factors are τ = 1, 5, 10 e 99 Gyr from top to bottom. The open circles correspond to violet, orange and marron for the mean values of models with t = 1, 5 e 13 Gyr, respectively.

References

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