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Analysis of galaxies through the fit of spectral energy distributions.

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Abstract. It is known that in the study of galaxies it is very important to examine which stellar populations constitute them. The aim of this project is analyze the formation and evolution of galaxies through the study of stellar population. Parameters are extracted from their Spectral Energy Distribution (SED), by means of fitting codes. This method was applied to a sample of photometric data from the astronomical Sloan Digital Sky Survey (SDSS) containing galaxies of the blue cloud, green valley and red sequence, from the Stripe 82 region. The Code Investigating GALaxy Emission (CIGALE) was used to compare the stellar population models with the SEDs of 15 galaxies in the sample, being 5 red, 5 green and 5 blue; randomly selected. It was obtained as a result an age range of 0.34 to 9.50 Gyr, masses between 7.40×10^8 and $4.00\times10^{11}\,M_\odot$ and metallicity Z ranging from 0.0004 to 0.05. These results were satisfactory and are in accordance with what is expected for each type of galaxy.

Resumo. Sabe-se que no estudo de galáxias é muito importante examinar quais são as populações estelares que as constituem. O objetivo deste projeto é analisar a formação e evolução de galáxias através do estudo das populações estelares que as compõem. Parâmetros são extraídos de sua distribuição espectral de energia (SED do inglês *Spectral Energy Distribution*), por meio de códigos de ajuste. Este método foi aplicado a uma amostra de dados fotométricos do levantamento astronômico *Sloan Digital Sky Survey* (SDSS) contendo galáxias do tipo nuvem azul, vale verde e sequência vermelha, da região *Stripe 82*. Utilizou-se o código *Code Investigating GALaxy Emission* (CIGALE) para comparar os modelos de população estelar com as SEDs de 15 galáxias da amostra, sendo 5 vermelhas, 5 verdes e 5 azuis; selecionadas de modo aleatório. Obteve-se como resultado um intervalo de idades de 0.34 a 9.50 Ga, massas entre 7.40×10^8 e $4.00\times10^{11}\,M_\odot$ e metalicidade Z variando de 0.0004 a 0.05. Tais resultados foram satisfatórios e estão de acordo com o esperado para cada tipo de galáxia.

Keywords. Galaxies: stellar content – Galaxies: evolution – Galaxies: formation – Method: data analysis – Techniques: photometric

1. Introduction

The galaxies spectral energy distribution (SED) fitting technique is a tool that has been used more and more in extragalactic astronomy (Walcher et al., 2011; Conroy, 2013). Each one of the physical processes are recorded in the spectrum of galaxies at certain wavelengths, so that by doing an analysis of SEDs, one can understand which properties involve this galaxy.

The technique consists of using a fitting code that takes into account theoretical models of stellar populations and compares them with observations. There is a wide range of SED fitting codes available, which predispose to different models, filters and statistical analyses.

2. Aims

The aim of this project is to study the stellar populations of galaxies through their parameters extracted from their SEDs, and to do so through learning the fitting codes.

3. Methods

The first step was to learn how to use an SED fitting code. The CIGALE was chosen (Code Investigating GALaxy Emission, Boquien et al., 2018) among those in the literature. The chosen data are galaxies from the local Universe observed by the SDSS (Fig. 1). After the characterization of the data, 15 galaxies was chosen from the sample, five from each classification, in order to test the code's operation.

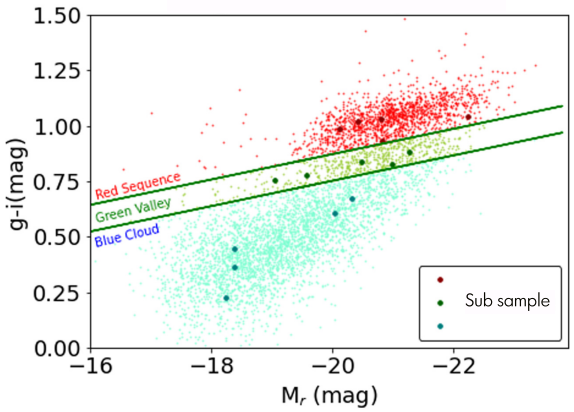

Figure 1. Color magnitude diagram of the sample, highlighting the 15 chosen galaxies.

4. Results

The fit of 5 photometric bands available in the SDSS was made for the 15 chosen galaxies. Figure 2 represents an SED fitted by CIGALE for a galaxy of the Green Valley group. The output parameters obtained for the best fit are shown in Table 1.

It is noticed a certain relationship between older galaxies having higher metallicities and higher masses, which is in line with expectations. But it's a small sample to infer anything.

Table 1. Parameters found for the chosen galaxies, where $M_\star$ is the total stellar mass, M_{gas} is the total gas mass, Age_M the mass weighted age and Z is the metallicity of the galaxy.

Object ID	$M_\star(M_\odot)$	$M_{gas}(M_\odot)$	Luminosity(W)	Age_M(Gyr)	Z	Color
1237663457778664101	(9.28±2.99)×E10	1.73E10	1.23E38	1.50	0.0004	
1237663544223727859	(7.40±1.71)×E8	1.78E8	1.26E36	0.57	0.0004	
1237663783662846140	(4.00±1.12)×E11	1.77E11	4.27E37	9,00	0.02	Red
1237663783664156791	(2.37±0.79)×E9	5.95E8	8.87E36	0.57	0.02	
1237663543675847377	(4.53±1.26)×E10	2.01E10	5.68E36	9.50	0.05	
1237666407365935200	(7.40±2.28)×E8	2.52E8	1.86E36	0.89	0.008	
1237663543148806319	(2.79±0.96)×E11	5.61E10	4.51E37	3.50	0.008	
1237657070092484687	(1.35±0.40)×E10	5.13E9	1.24E37	5.37	0.02	Green
1237666299484373252	(5.00±1.43)×E10	1.46E10	7.66E37	1.53	0.02	
1237663783131152550	(3.55±1.00)×E10	1.56E10	2.74E37	4.99	0.02	
1237663543675520551	(1.95±0.62)×E9	3.53E8	2.51E36	1.15	0.0004	
1237663239271940430	(4.38±1.24)×E10	1.88E10	5.31E36	1.50	0.05	
1237663542605252155	(1.38±0.42)×E10	3.30E9	2.44E37	6.31	0.0004	Blue
1237666340801020030	(2.42±0.89)×E9	4.77E8	3.39E36	0.57	0.02	
1237663462606635126	(9.54±2.33)×E8	2.29E8	3.42E36	0.34	0.004	

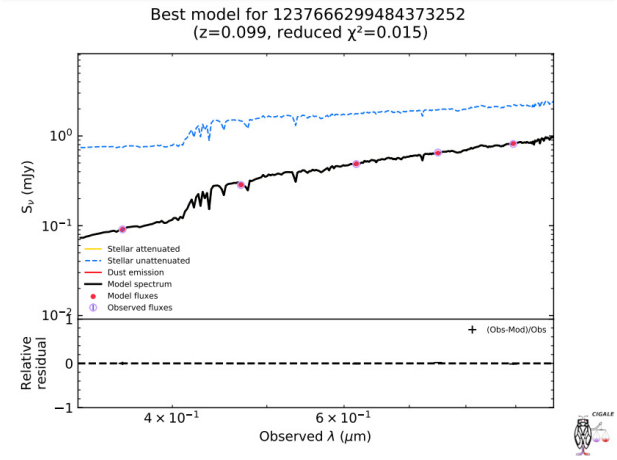

Figure 2. SED fitted by the CIGALE for a Green Valley galaxy.

5. Conclusions

The aim of understanding how the galaxy SED fitting technique works was achieved. The parameters obtained for the small sample were consistent with the expected for each object and the next step will be to focus on a type of galaxy to obtain a more detailed analysis. The younger galaxies belonging to the Blue Cloud group will be investigated in the continuation of the project.

Furthermore, it is intended to evaluate CIGALE in different configurations, changing the models of stellar populations, star formation history, initial mass function, and so on. Also change or expand photometric bands to understand how much all of this can impact the final result.

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