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Photospectral synthesis of galaxies in the middle age of the Universe

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Abstract. Detailed full spectral synthesis studies of the stellar populations in galaxies are usually restricted to the local Universe (z ≤ 0.1), where data are more abundant. From this kind of study, inferences are made about the evolution of galaxies. A more direct way to study this evolution is through the analysis of galaxies at intermediate and high redshift. Spectroscopic observations from the Large Early Galaxy Astrophysics Census (LEGA-C) of galaxies at redshift's around 0.6 – 1.0 allow spectral synthesis studies similar to those performed in the Local Universe, but for systems only half as old. However, the spectral window covered by the observations span only about 3000 Å. These spectra are complemented with photometric measurements from a wealth of sources (SUBARU, HST, among others) and this pan-spectral data-set allows more reliable stellar populations analysis than one based only on the optical spectrum. The data cover a range of wavelengths from the FUV band, at $\lambda \sim 1500$ Å, to the K band, in the infrared at $\lambda \sim 21500$ Å. Photometric and spectroscopic data are fitted simultaneously with the latest version of the STARLIGHT code. The photo-spectral fits obtained are excellent. The intrinsic properties (masses, average age and metallicity, extinction, star formation history) derived from these fits will allow for detailed studies of these objects. Here we present the method, fits and some preliminary results on the rejuvenation of quiescent galaxies.

Resumo. Estudos detalhados de síntese espectral de populações estelares em galáxias são normalmente restritos ao Universo local (z ≤ 0.1), onde dados são mais abundantes. Desse tipo de estudo são feitas inferências sobre a evolução das galáxias. Uma maneira mais direta de estudar essa evolução é através da análise de galáxias à distancias cosmologicamente interessantes (isto é, alto redshift). Observações espectroscópicas com o telescópio VLT do Large Early Galaxy Astrophysics Census (LEGA-C) de galáxias a redshift's em torno de 0.6 – 1.0 permitem estudos de síntese espectral semelhantes aos realizados no Universo local, mas para sistemas com a metade da idade. Contudo, a janela espectral de observação usualmente cobre apenas cerca de 3000 Å, os dados espectrais são complementados com medidas fotométricas de várias fontes de dados (SUBARU, HST, entre outras) e esta base pan-espectral permite analises de populações estelares mais confiáveis do que aqueles baseados apenas no espectro óptico. Os dados cobrem uma faixa de comprimentos de onda varrendo desde a banda FUV, em $\lambda \sim 1500$ Å, até a banda K, no infra-vermelho em $\lambda \sim 21500$ Å. Os dados fotométricos e espectroscópicos são ajustados simultaneamente com a última versão do código STARLIGHT. Os ajustes foto-espectrais obtidos são excelentes. As propriedades intrínsecas (massas, idade e metalicidade média, extinção, história de formação estelar) derivadas desses ajustes permitem estudos detalhados desses objetos. Neste trabalho apresentamos o método, os ajustes e alguns resultados preliminares sobre o rejuvenescimento de galáxias quiescentes.

Keywords. Galaxies: stellar content – Galaxies: high-redshift – Methods: data analysis

1. Introduction

Stellar populations are the result of galaxies evolution across time, so studying them can provide information on how galaxies evolve. High quality data are needed to carry out such studies, which usually restricts samples to the local Universe. Between the years of 2014 and 2018 the LEGA-C survey (van der Wel et al. (2016)) carried out 20 hours integrations with the VLT-ESO to collect high quality $z \sim 0.6$–1 galaxy spectra from 6000 to 9000 Å in the observed frame. These spectra are complemented by photometry from COSMOS survey (Scoville et al. (2007)), extending the observations towards both the blue and red sides of the spectral window.

This pan-spectral dataset can provide stellar populations fit more constrained that those made by the spectra alone. A typical galaxy spectrum and photometry is shown in figure 1.

2. Method

LEGA-C spectroscopic and COSMOS photometric data are simultaneously fitted by using the STARLIGHT code (Cid Fernandes et al. (2005)) in its latest version (described in Werle (2019)). We are using a spectra base of 98 stellar populations spectra covering 14 ages, from zero to 8.5 Gyr (z ≤ 1), and 7 metallicities. By combining the base elements and taking into account kinematics and dust attenuation, STARLIGHT creates a synthetic model, which we chose to normalize in units of the flux in the 4020^{+40}_{-10} Å (rest-frame) range, chosen as a relatively featureless spectral window that is shared between all spectra in our sample.

Observed and synthetic data are shown in figure 1, where the top plot covers the entire fitting range, and bottom plot covers the region with observed spectroscopic data, both in the rest-frame.

3. Results and Conclusions

Using the fits from STARLIGHT, we can start to look at galaxies in a statistical manner. First, as a selection criteria, we selected quiescent galaxies using a UVJ diagram, elliptical by looking at sersic index ≥ 2.5, with S/N ≥ 10, shown in Figure 2. Using this sub sample, in search of rejuvenating quiescent galaxies, we can look at one of the most important results of this kind of analysis, the star formation history (Figure 3).

We notice that low stellar metallicities are more prominent among older populations, consistent with chemical evolution, though the high concentration of $Z = 0.06$ populations is somewhat suspicious and possibly an artifact induced by the redder (more Z-sensitive) bands included in the analysis. These and other results are currently being studied in more details.

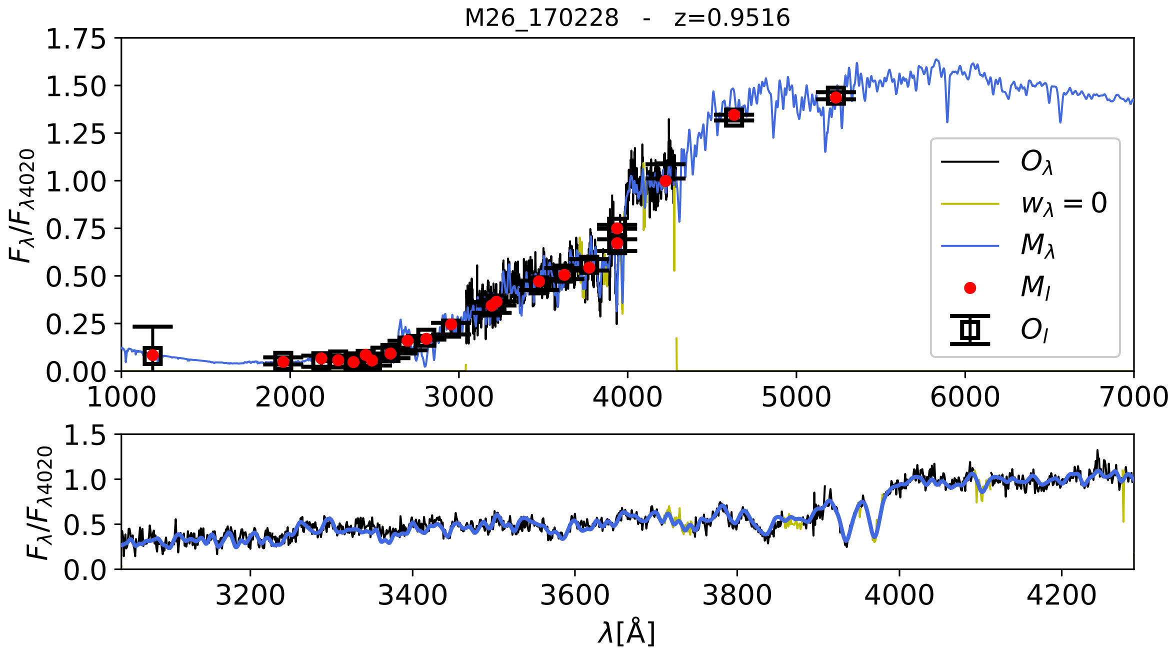

Figure 1. Photospectral synthesis result of M26_170228, where black line, black boxes with error bars, blue line, red dots and yellow line are observed spectra, observed photometry, synthetic spectra, synthetic photometry, and masked regions for the synthesis, respectively. X-axis is wavelengths in Åand Y-axis is light fraction in 4020 Å, bottom covers the region with observed spectroscopic data.

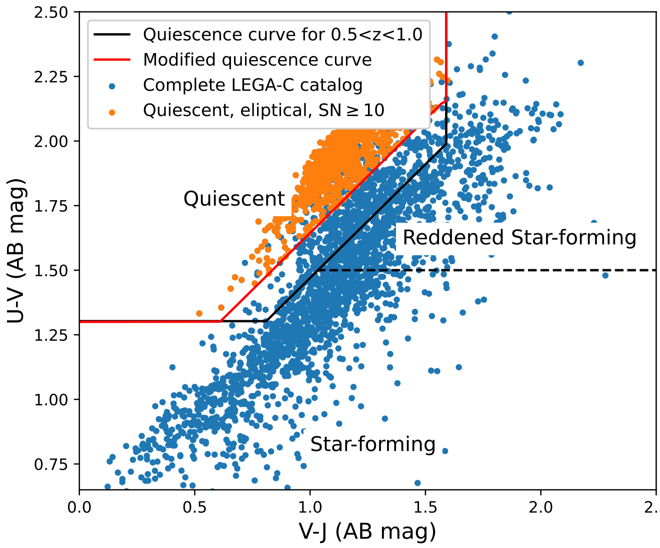

Figure 2. Subsample selection by using UVJ diagram, Sersic Index, and S/N ≥ 10, we modified the quiescence curve to better avoid starforming galaxies.

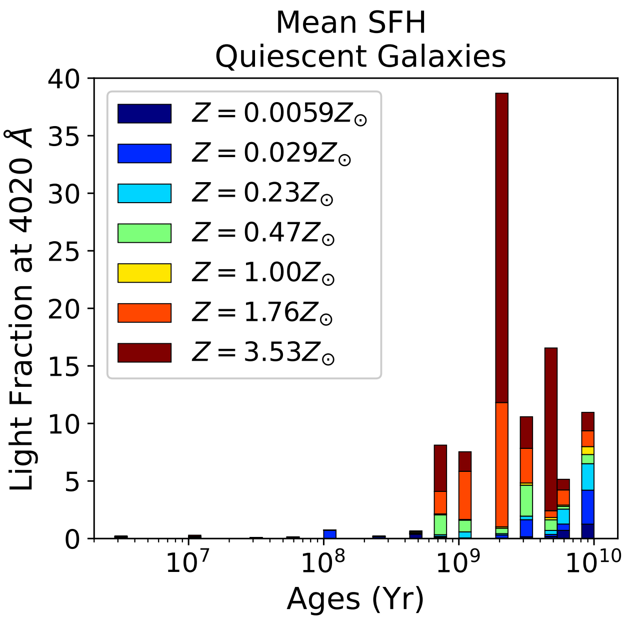

Figure 3. Mean Star formation history of our subsample defined in figure 2 in light fraction at 4020Å .

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