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The environment of local analogues to high-redshift star forming galaxies

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Abstract. The main goal of this project is to investigate the environment of high-redshift analog galaxies, i.e., objects that have similar properties to high-redshift galaxies but are found in the local universe, such as the Lyman Break Analogs and the Green Peas, in order to better understand the influence of the environment on its physical properties. These results are then compared with distant galaxies, in order to allow for a better evaluation of the influence of the local environment on the formation of galaxies 10 billion years ago. We have developed a code that can analyze the fields of the analogues, measure their respective densities using the kth-nearest neighbor method with $k = 4$, 5 and 10, and compare the density values with different k's with each other. To perform this analysis, we used data from the SPLUS survey, an imaging survey in 12 magnitude bands using the T80-South telescope, at the Cerro Tololo Observatory. We have also used the inferred photometric redshifts from said catalogue. Within our main sample, we have thus far found 14 LBAs and 42 Green Peas. Our preliminary results show that the densities of the analogues are generally higher than the average densities of galaxies in the same data. The next step of our project is to perform the analysis with more recent data releases from the same survey, with more significant statistical sampling, resulting in more accurate data about the environment in which the analogues are found. Furthermore, we will analyze how the star formation rate and the specific star formation rate behave in relation to the density of the medium.

Resumo. O objetivo principal deste projeto é investigar o ambiente de galáxias análogas de alto redshift, i. e., objetos que possuem propriedades similares às galáxias em alto redshift mas estão no universo local, como as Lyman Break Analogs e as Green Peas, a fim de entender melhor a influência do ambiente sobre suas propriedades físicas. Estes resultados são então comparados com galáxias distantes, de modo a permitir uma avaliação da influência do ambiente local sobre a formação de galáxias há 10 bilhões de anos. Nós desenvolvemos um código que possa analisar os campos das análogas, medir suas respectivas densidades utilizando o método da k-ésima vizinha próxima com $k = 4$, 5 e 10, e comparar os valores das densidades com ks diferentes entre si. Para realizar essa análise, utilizamos os dados do levantamento SPLUS, que é um survey de imageamento em 12 bandas de magnitudes usando o telescópio T80-South, no Observatorio Cerro Tololo. Também utilizamos os redshifts fotometricos calculados presentes neste catálogo. Dentro dessa nossa amostra principal, encontramos até o momento 14 LBAs e 42 Green Peas. Nossos resultados preliminares mostram que as densidades das análogas são em geral maiores que a média de densidades de galáxias presentes nos dados. O próximo passo do nosso projeto é passar a análise para os dados mais recentes deste levantamento, com amostragem estatística mais significativa, resultando em dados mais acurados sobre o ambiente em que as análogas estão inseridas. Além disso, analisaremos como a taxa de formação estelar e a taxa de formação estelar especifica se comportam em relação à densidade do meio.

Keywords. Galaxies: evolution – Galaxies: high-redshift – Galaxies: starburst – Galaxies: interactions

1. Introduction

Galaxies in the distant universe form significantly more stars per unit of time (Whitaker et al. 2012), but there is still debate on whether there is any relation of this effect with the environment in which they are embedded. In order to investigate this possible connection, we analyze the medium of star-forming galaxies analogous to those in high-redshift. These samples are typically present in the local universe and have similar properties to star-forming galaxies in the distant universe. Lyman Break Analogs, for example, are similar to Lyman Break Galaxies (LBGs) in luminosity, mass, star formation rate, specific star formation rate, UV attenuation and metallicity (Hoopes et al. 2007). Green Peas, on the other hand, are similar UV-luminous high-redshift galaxies in size, morphology, large emission lines, reddening and star formation rate (Cardamone et al. 2009).

2. Sample

Our main sample consists of the DR1 of the SPLUS, an imaging survey of $\sim$ 336 deg^2 of the SDSS Stripe 82 field using the 12 magnitude bands of the Javalambe magnitude system. These comprise 5 broad-bands (ugriz) and 7 narrow-bands (centered on the Balmer jump/[OII], Ca H+K, Hδ, G-band, Mg b triplet, Hα and the Ca triplet), using the T80-South telescope, at the Cerro Tololo Inter-american Observatory. In addition, the SPLUS-DR1 also provides the photometric redshift, calculated with the Bayesian Photometric Redshift (BPZ2) code (Molino et al. 2019), and have a precision of $\delta_z/(1 + z) = 0.03$ or better for a magnitude $r < 20$ or a redshift $z < 0.5$. The narrow-band filters are key to reaching such high precision for the photometric redshifts. Within that initial sample there are 14 LBAs and 42 Green Peas.

Table 1. p-value of the Kolmogorov-Smirnov test for the different densities, and the three samples

	DR1-LBAs	DR1-Green Peas	LBAs-Green Peas
$\log(\Sigma_{k4})$	0.1740	0.0141	0.6653
$\log(\Sigma_{k5})$	0.1507	0.0086	0.7973
$\log(\Sigma_{k10})$	0.1260	0.0048	0.4081

3. Methodology

To calculate the density of the environment we use the methodology described in Santana-Silva et al. (2020) and Darvish et

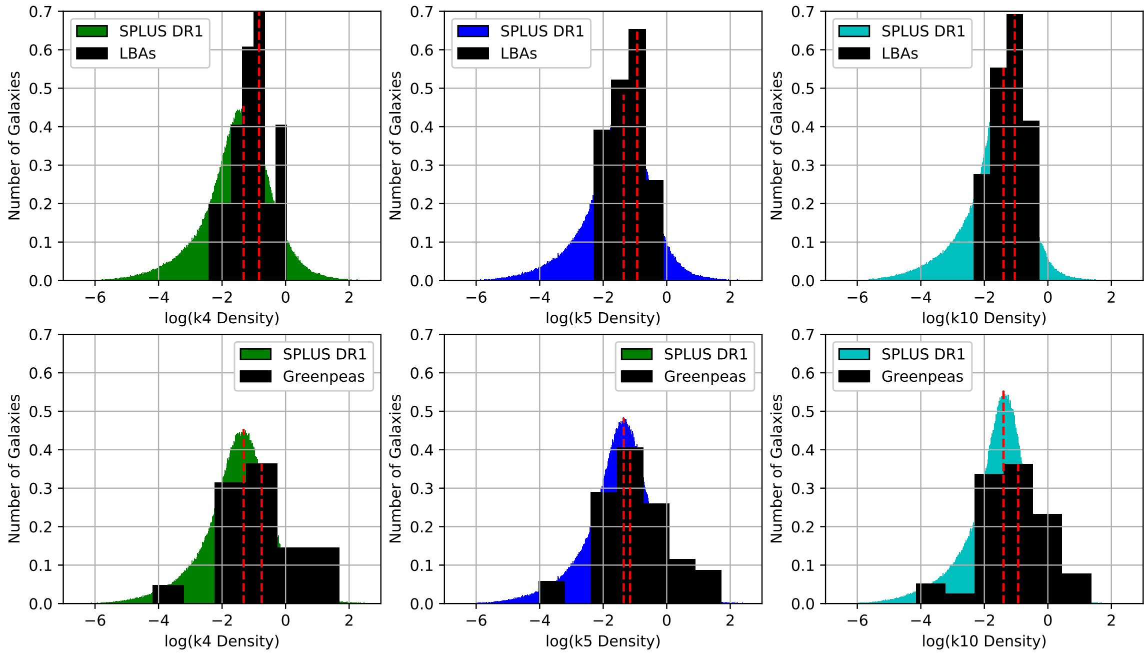

Figure 1. Top row: Histogram of the LBAs densities in black, compared to the densities of the DR1 of SPLUS (Green: $k = 4$, Blue: $k = 5$, Cyan: $k = 10$). Bottom row: Histogram of the Green Peas densities in black, compared to the densities of the DR1 of SPLUS (Green: $k = 4$, Blue: $k = 5$, Cyan: $k = 10$). In both rows we have a vertical dashed red line representing the mean value of the distributions.

al. (2018). We select the k-th nearest neighbors to the galaxy within a redshift slice of of $c\Delta z = \pm 2000\,km\,s^{-}1$ to take into account possible projection effects along line of sight. We measure the two-dimensional distance in Mpc between them and apply a correction function (ψ) to take correct for completeness at larger distances, thus obtaining a surface density given by

$$\Sigma = \frac{k}{\pi D_k^2} \frac{1}{\psi}. \qquad (1)$$

In order to determine how the density of the environment changes on small and large scales, we use $k = 4, 5$ and 10.

4. Results

Preliminary results are shown in Figure 1. Environmental densities for the analogs using $k = 4$ and 5 are greater than the density of the entire SPLUS sample. This is in agreement with Santana-Silva et al. (2020), who show that LBAs reside in pairs or small groups up to 4 members instead of large clusters. This result also agrees with the literature and is interpreted as indication that LBAs are passing through early stages of preprocessing. For larger scales ($k = 10$), the densities of around analogs is significantly greater than the field densities, in disagreement with Santana-Silva et al. (2020), who showed that LBAs are not present in large clusters, but rather in small groups.

To verify the statistical reliability of these results, we have performed a Kolmogorov-Smirnov test for two samples in order to determine whether we can consider the samples as distinct. The p-value of the test (see Table 1) showed us that the environment of green peas is indeed higher than the sample average, but the LBA sample is not large enough to allow for us to draw a more definite conclusion.

5. Conclusions

Our preliminary results indicate that our sample of analog galaxies are found in denser environment than the average of galaxies at all physical scales. This agrees with earlier results by Santana-Silva et al. (2020) for small scales, but disagrees with this work at larger scales. This is still dependent on small numbers, however, and a larger sample is needed to confirm these results. We therefore intend to use the SPLUS-DR2 next, in an attempt include more analogs. This will provide us with more accurate and statistically significant data on the environment of star-forming galaxies. We will also analyze the density as a function of SFR/sSFR, in order to perform such comparison for galaxies with similar physical properties to the ones investigate in this work.

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