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The role of environment in the properties of local analogs to high-redshift galaxies

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Abstract. The main sequence of star-forming galaxies shows a trend between their star formation rate (SFR) and mass, but some galaxies deviate from this pattern. Lyman Break Analogs (LBAs) have similar properties to high redshift galaxies but are found at lower redshifts. This study uses Sloan Digital Sky Survey (SDSS) data to examine the environmental influence on LBAs by measuring their local density with the nearest neighbor method. Our goal is to assess if environmental factors impact the observed properties of LBAs compared to other nearby galaxies with similar characteristics.

Resumo. A sequência principal de galáxias de formação estelar mostra uma tendência entre a sua taxa de formação estelar (SFR) e a massa, mas algumas galáxias desviam-se deste padrão. Os análogos de Lyman Break (LBAs) têm propriedades semelhantes às galáxias com alto redshift, mas são encontrados em redshifts mais baixos. Este estudo utiliza dados do Sloan Digital Sky Survey (SDSS) para examinar a influência ambiental nos LBAs, medindo sua densidade local com o método do vizinho mais próximo. Nosso objetivo é avaliar se os fatores ambientais impactam as propriedades observadas dos LBAs em comparação com outras galáxias próximas com características semelhantes

Keywords. Galaxies: high-redshifts - Galaxies: groups: general - Galaxies: star formation

1. Introduction

The main sequence of star-forming galaxies is an increasing trend within an observed group of galaxies, reflecting the relationship between the Star Formation Rate (SFR) and their masses. However, some galaxies deviate from this sequence, and current literature suggests that, besides mass, the environment can be a determining factor in this behavior. Lyman Break Analogs (LBAs) are galaxies with properties, such as SFR and mass, similar to high-redshift galaxies but located in low redshifts. By studying the surroundings of Ultraviolet-luminous Galaxies using data from the Sloan Digital Sky Survey (SDSS), we can evaluate the influence of the environment on the observed properties of these objects. This research investigates the environmental density around LBAs, comparing their properties with those of other nearby galaxies with similar characteristics. We employ the nearest neighbor method to measure the physical density around each galaxy in our selected sample, aiming to verify the role of the environment in shaping the properties of LBAs.

2. Methods

We established the defining properties of the LBAs using the criteria outlined in Hoopes et al. (2007), as shown in Table 1, to select supercompact UVLGs as analogs of LBGs from a sample of 108 galaxies and their neighbors observed by the Sloan Digital Sky Survey.

The k-nearest neighbor (KNN) method operates under the assumption that galaxies with proximate neighbors are situated in regions of higher density. For a given value of k, the distance to the k-th nearest neighbor of a target galaxy is measured and used to calculate the projected surface density, δ_k

$$\delta_k = \frac{k}{\pi r_k^2}$$

We then account for the fact that two galaxies may appear closer together than they actually are due to projection effects. To mitigate this, we apply velocity or redshift cuts around the target galaxy, thereby defining the projected density of the region surrounding the galaxy i, Σ_i,

$$\Sigma_i = \frac{1}{\psi(D_i)} \frac{k}{\pi d_i^2}$$

where, d_i is the comoving distance to the k-th nearest neighbor, and $\psi(D_i)$ is the selection function to correct for the Malmquist bias.

$$N(D)dD = AD^2\psi(D)dD$$

$$\psi(D) = e^{-(\frac{D}{D_c})^\alpha}$$

A is a normalization parameter, D_c it is a characteristic comoving distance corresponding to the peak of the redshift distribution, D is the comoving distance, and $N(D)$ is the number of galaxies with measured D.

3. Results

The environmental dependence of the SFR comparing the estimated surface densities using the 4th, 5th and 10th nearest neighbors is used to analyze the properties of the selected LBAs with those of other galaxies in the sample, as shown in the Figure 1.

Table 1. Physical parameters from Table 2 in Hoopes et al. (2007), with alterations to show only the properties used in the galaxy selection of high-redshift analogs.

Parameter	Compact UVLGs ($I_{1530} > 10^8 L_\odot kpc^{-2}$)	Supercompact UVLGs ($I_{1530} > 10^9 L_\odot kpc^{-2}$)	LBGs
$\log L_{1530}(L_\odot)$	10.3 a 11.0	10.3 a 10.9	10.3 a 11.3
$\log I_{1530}(L_\odot kpc^{-2})$	8.0 a 10.3	9.0 a 10.3	9.0 a 10.0
$\log R_{50,u}$	-0.5 a 0.8	-0.5 a 0.4	0.0 a 0.5
$\log M_*(M_\odot)$	9.2 a 11.0	9.0 a 10.7	9.5 a 11.0
$\log SFR(M_\odot yr^{-1})$	0.2 a 2.0	0.5 a 2.0	0.5 a 2.5

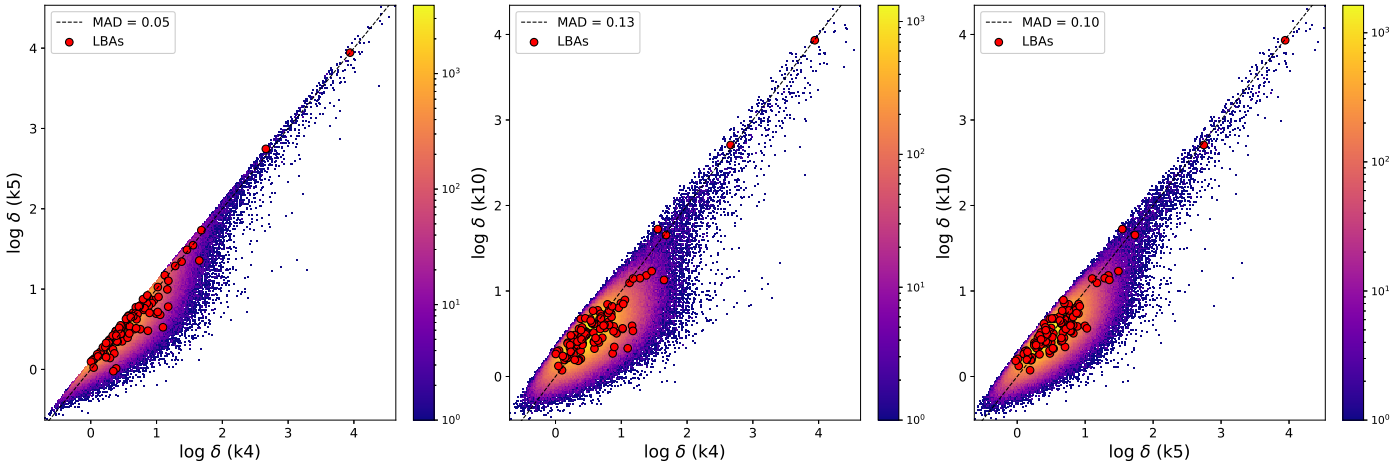

Figure 1. Surface densities compared using the 4th and 5th nearest neighbors (left), 4th and 10th nearest neighbors (middle), and 5th and 10th nearest neighbors (right). The color scale represents the number of galaxies, ranging from purple (indicating fewer galaxies) to yellow (indicating more galaxies), with the 108 selected LBAs highlighted in red.

This provides insights into the possible influences of the environment on the SFR and mass of the galaxies.

The results show that the selected LBAs are in environments with density within the same range as the general galaxy sample. Galaxies located in regions with density values greater than 0.7 may be in pairs or groups, and regions denser than 1.5 are associated with clusters. We did not find galaxies with these density values in the measurements for the selected sample, as we can see in Figure 1.

4. Conclusions

The selected LBAs are not associated with galaxy clusters and this result was limited by the fact that SDSS does not detect very faint galaxies. Therefore, detecting low densities may be a result of the survey's incompleteness, which does not present a significant number of higher magnitude objects. This result, in particular, could be better analyzed with deeper images where fainter galaxies inhabiting the environment of the selected LBAs could be detected.

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