A Serendipitous Survey for Extremely Distant Galaxies

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Abstract

Using data obtained from the Observations of Redshift Evolution in Large-Scale Environments (ORELSE) survey, deep spectrographic observations of galaxy clusters around redshifts 0.6 to 1.3 were obtained. The data we are using was taken with long exposure times in certain patches of the night sky using the DEIMOS instrument on the Keck telescope. We present our findings on a collection of galaxies that were indirectly observed from this survey called Lyman-alpha emitters. These are young, high redshift galaxies that contain hydrogen gas that is being ionized by star formation and emits light at 1215.67 angstroms. This survey never targeted LAEs but they were observed by happenstance. For each cluster, slit spectra were obtained for individual galaxies. Each of these spectra were visually inspected for the possible presence of the Lyman alpha emission line and then were analyzed further to obtain redshift information. Finally, we have produced a redshift histogram, plotting the number of LAEs found per redshift.

Keywords: galaxies, LAES, template

1. Introduction

The Lyman-alpha (lya) line is a spectral emission line caused when ultraviolet light of 1215.67 angstroms is emitted from a hydrogen atom due to the de-excitation of an electron from the n=2 level to the n=1. This line can be detected in Lyman Alpha emitter (LAE) galaxies where star forming regions can ionize the neutral hydrogen found in these high redshift galaxies. We want to look for and characterize these populations because they can give us insights on the star formation rates of galaxies when the universe was young.

LAEs can be detected from Earth based observatories by using custom-made, narrow band filters that look in wavelengths not obscured by emission lines from Earths atmosphere, and narrow in on specific, red shifted wavelengths of LAEs according to their distance from us

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(Hu et al.). Around z=3 is where the UV light becomes red shifted into visible wavelengths, detectable on Earth, because the atmosphere is opaque in the UV. LAEs can also be found from space telescopes that can see above the atmosphere that is filled with contaminating spectral lines caused by the molecules within Earth's atmosphere.

2. Method

Multi-object spectrographs allow surveys of emission line galaxies to be conducted by obtaining deep, high resolution spectra of patches of the night sky that are void of contaminants. The data being used is from the Observations of Redshift Evolution in Large-Scale Environments (ORELSE) Survey (Lubin et al. 2009). This survey targeted 20 galaxy clusters and studied their large scale structure. For the purpose of this project, we will analyze the 1604 cluster only. Each field observed, used slit masks that were capable of obtaining high resolution spectra of up to 120 plus individual galaxies.

The instrument used for obtaining the spectra was the Deep Multiobject Imaging Spectrograph (DEIMOS; Faber et al. 2003) that is being used on the W.M. Keck 10 meter telescope on top of MaunaKea on the Island of Hawai'i. DEIMOS has a large field of view of 16'.7 by 5'.0 allowing it to view a decent portion of the sky.

The method for analyzing this large amount of data involved the visual inspection of each slits spectrum, a 1 dimensional spectrum inspection, a redshift fitting and finally visual slit overlay. For each slit, we will be searching for isolated single emission lines that are nebular, asymmetric features that appear without a corresponding continuum, that feature a blue-ward trailing tail and a sharp redward peak. The Lya line will appear as a continuum break of around 1.3-4.5 mag. These will serendipitously appear on our slits as they were not initially targeted in the survey, we will call these objects serendips. Figure 1 is a good potential candidate as it has no continuum and clearly has a blue-ward trailing tail. One challenge to overcome is differentiating the Lya line from oxygen lines and other hydrogen lines. Figure two is not a viable LAE candidate as it is a doublet emission feature that shows a continuum. Varying intensities and spectral features also help to make distinctions. Low redshift interlopers are another possible cause for false positives and will be distinguished via faint associated lines.

After the initial visual inspection of the two dimensional slits, IDL will be used to extract the spectrum from the slits which will allow us to view a one dimensional representation of the spectra plotting brightness against wavelength. This extraction process incorporates that centroid of the emission line and its full width half max (FWHM). One test we will utilize is the effective redshift test that will determine what redshift a galaxy would have if its observed emission line is the Lya line. We obtain redshift estimates inside of IDL using a program called ZFIND that attempts to fit a potential redshift for different emission lines such as the lyman alpha line or oxygen. Setting the redshift range to fit over along with the wavelength interval for our candidate helps in achieving accurate red shifts. Another method that will help determine LAE candidates is by overlaying the slit cutout from the

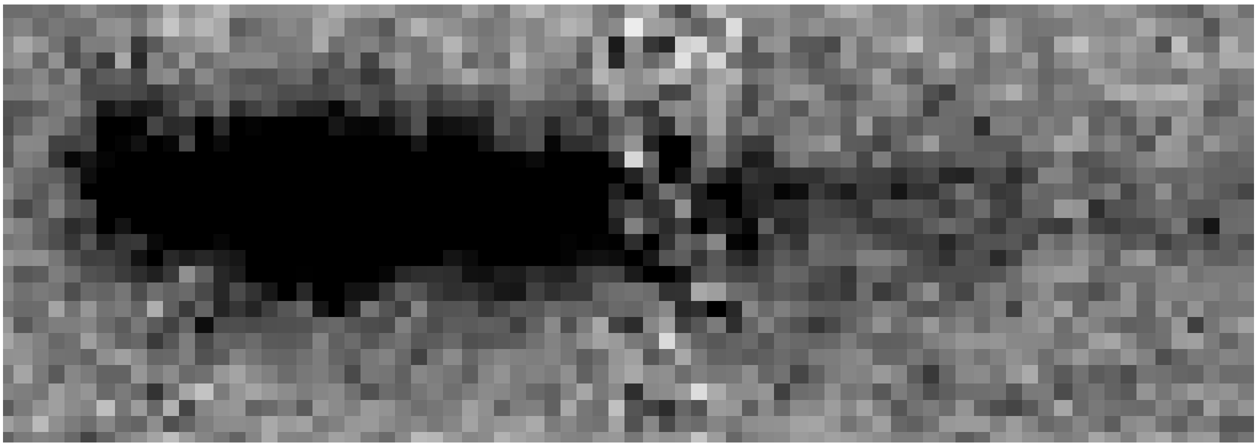

Figure 1: An example of a good candidate LAE.

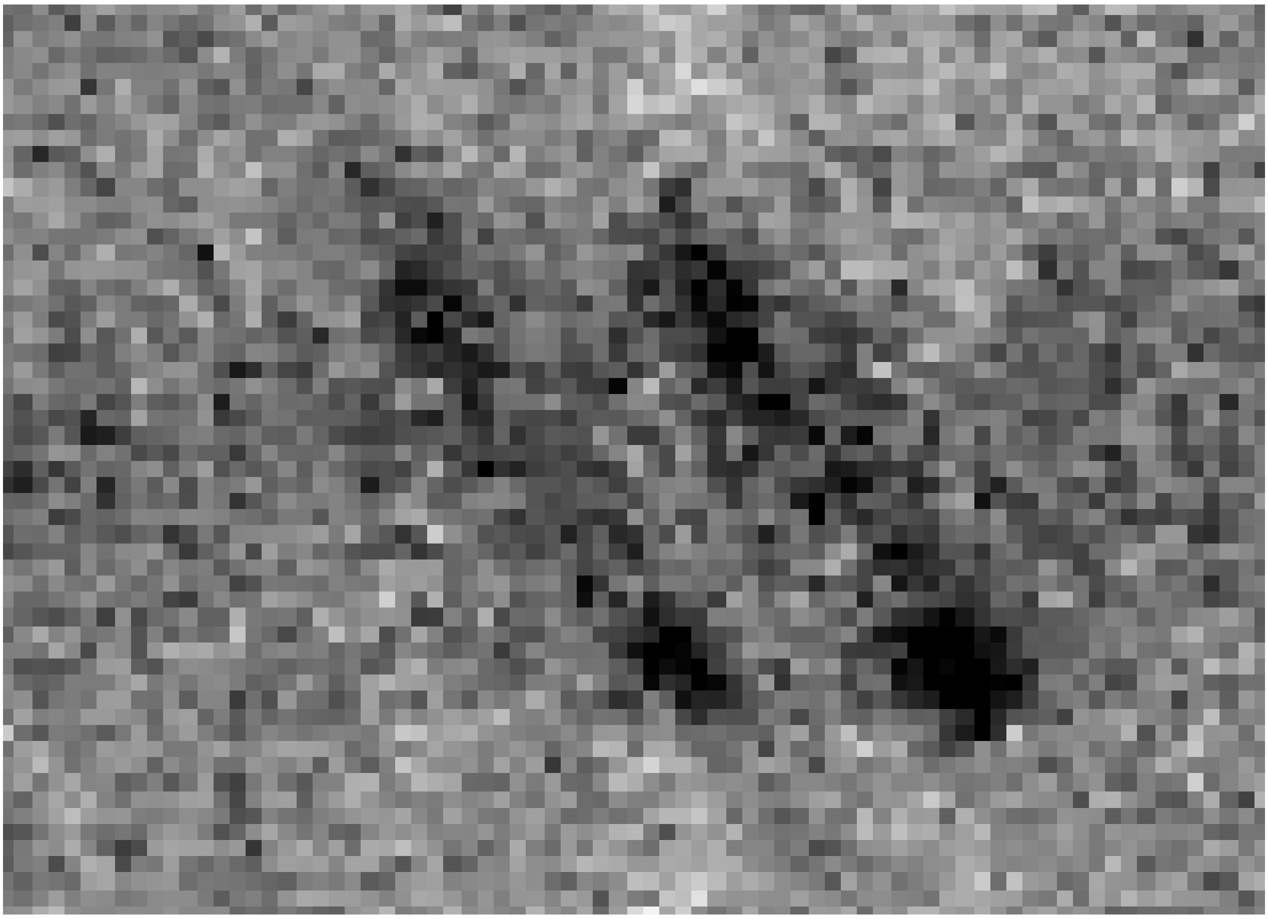

Figure 2: A doublet emission line

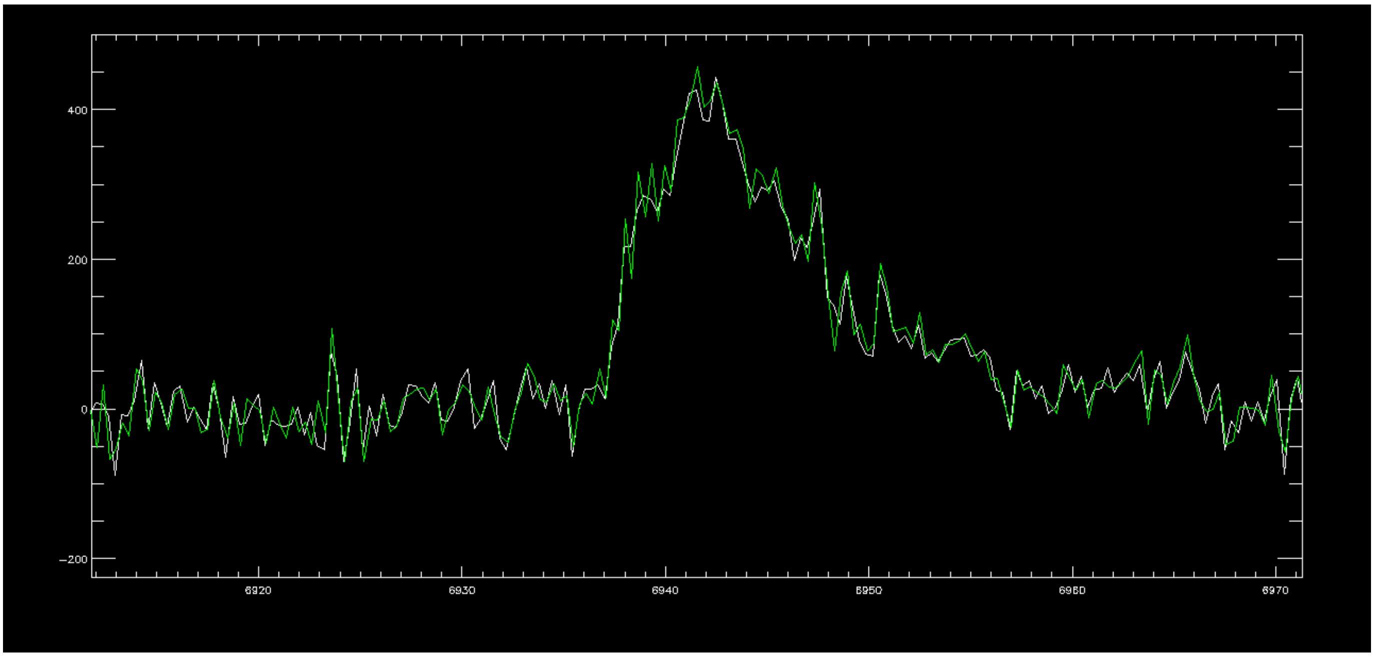

Figure 3: A good example of the asymmetric Lyman Alpha emission line in its 1D spectrum

mask, on top of our found objects and the survey targeted object in one image. If an object appears in the area where a serendip is found, it is most likely not a LAE due to the image being in the r'-band.

3. Results

Visual inspection of the two dimensional spectrum have so far yielded 50 potential LAE candidates. The candidates appear on the spectrum in many different ways. Some are bright and obvious such as the candidate depicted in figure 1. Most of the candidates appear as small nebulous objects. A few objects unfortunately lie on skylines and other spectral artifacts. After the analysis, 14 objects remained candidate LAEs and a histogram (figure 5) of their red shifts was produced. A noticeable peak in red shifts is found around the redshift interval 4.80 to 5.10. This could be due to the fact that the DEIMOS instruments sensitivity peaks around 7000 angstroms which is around where the majority of our LAE candidates wavelength's have been red shifted to. This peak could also be due to some clustering of high redshift galaxies in the cosmos.

4. Conclusions

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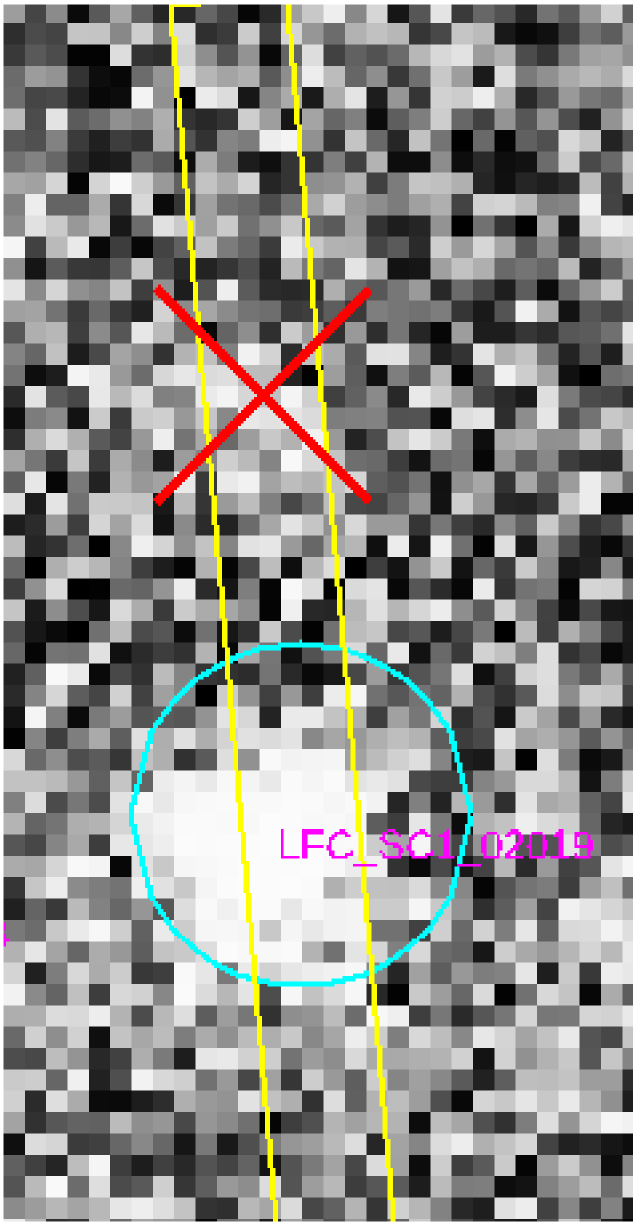

Figure 4: An image of the area, slit spectra was taken from.

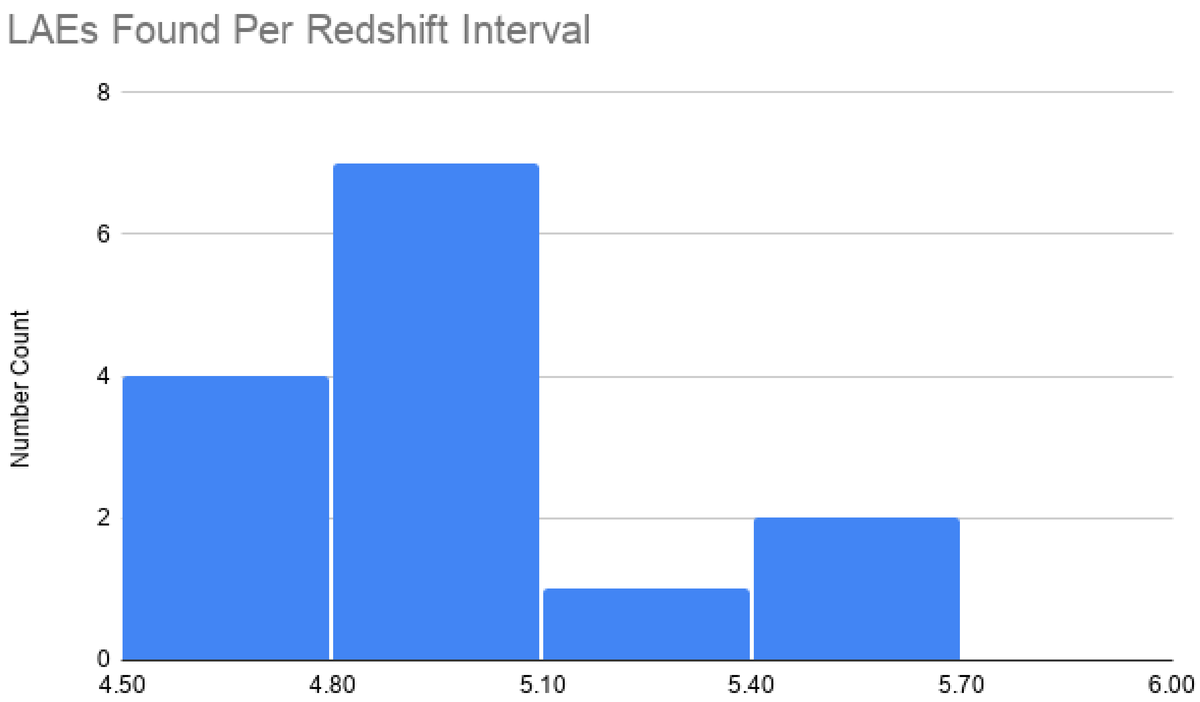

Figure 5: The number of candidate LAEs discovered and their red shifts

6104374.

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Appendix