A New Method to Select Lyman Alpha Emitters at Redshift ~ 7

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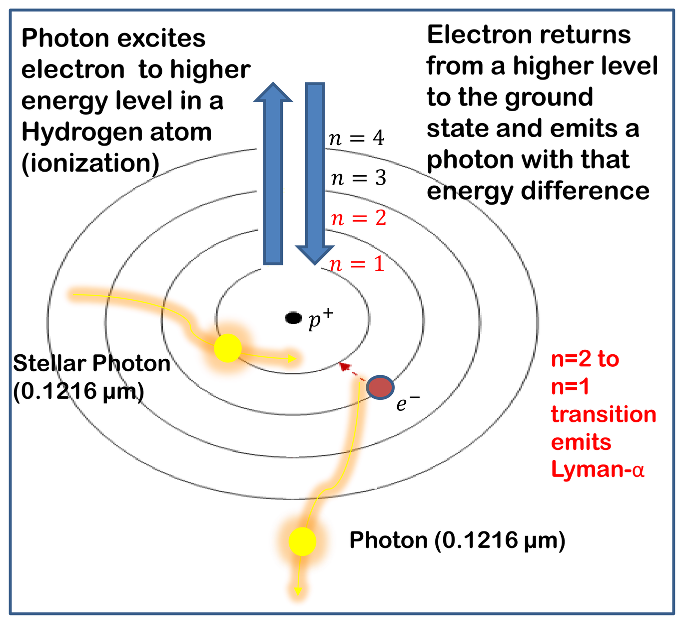
Abstract

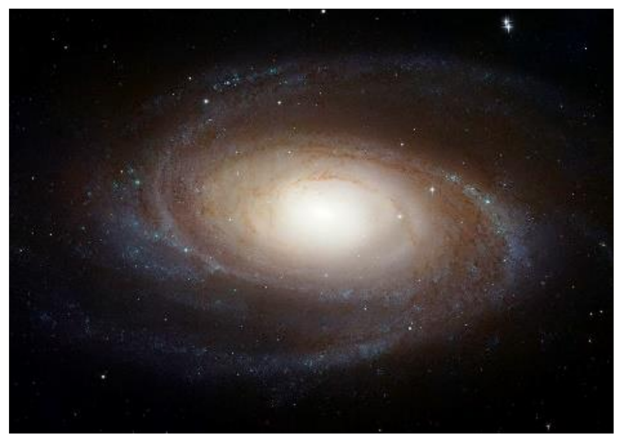
The Lyman-alpha emission line is the most common transition associated with ionized neutral Hydrogen. It is effective at tracing ionizing radiation from intense star formation in young galaxies. Previous studies find that the Lyman-alpha emission in galaxies decreases in strength with increasing redshift (earlier in the Universe). This has big implications at z~7, when Lyman-alpha is expected to be produced as a result of the Universe's reionization. In this study, we develop a method to select galaxies in the CANDELS fields that have strong Lyman-alpha emission by taking advantage of existing broadband Hubble and Spitzer photometry. By modeling the spectral energy distributions (SED) from objects with robust photometric redshifts, we determine the best-fit SED that is blind to the data around the Lyman-alpha line, thus using the rest of the SED to make an upper-limit prediction the Lyman-alpha line. We find that Lyman alpha emission is more likely to be present in UV luminous galaxies. These Lyman alpha emitting candidates will be followed up in an upcoming HST grism survey by PI Casey Papovich.

Introduction

Energetic photons from star-forming regions are able to ionize electrons in neutral hydrogen atoms. As the electrons recombine and cascade down the energy levels, they prominently produce Lyman-alpha radiation.

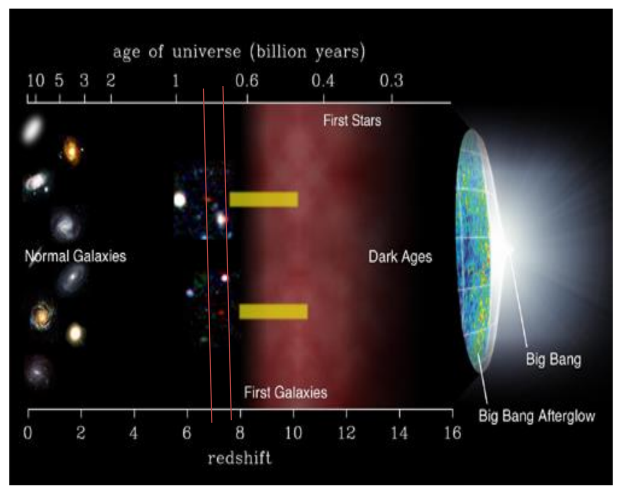
Since the 2-to-1 Lyman-alpha transition is the most common, the Lyman-alpha emission line is the most characteristic feature in the SEDs of star-forming galaxies.



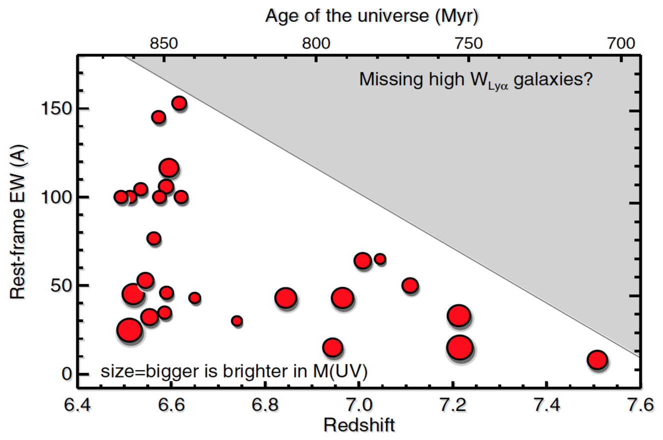


Galaxies are comprised of stars, dust, and neutral gases, such as hydrogen. Through the detection of Lyman-alpha emission, we are able to confirm the redshifts, z, of distant galaxies, and search for galaxies with intense star formation. However, dust and line-of-sight neutral gas in the intergalactic medium (IGM) can obscure Lyman-alpha emission making searches at z > 6 difficult.

Galaxies in the early Universe are just now being surveyed in large numbers by deep space (HST, CANDELS) and ground based programs. The early Universe went through a fundamental phase transition from being primarily opaque to photons, to being re-ionized by the first galaxies. Reionization is believed to be complete at z < 6, making the z ~7-10 a critical era for constraining early galaxy evolution.



Motivation

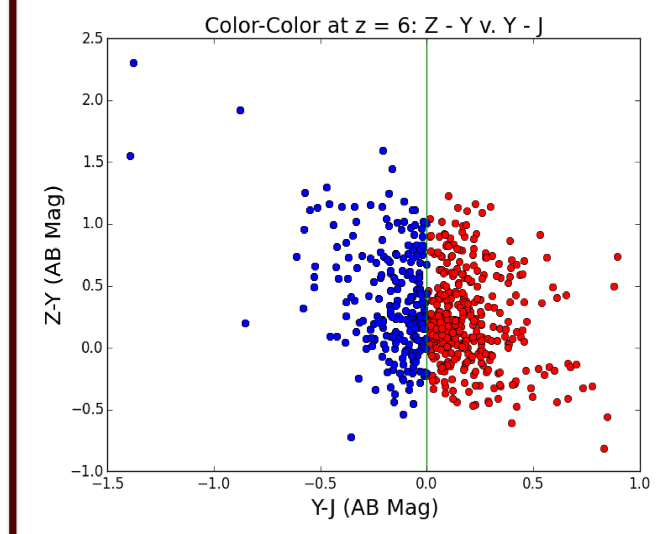


The above figure from Tilvi et al. (2014), shows the strength of the Lyman-alpha line in galaxies as a function of redshift. Galaxies in the early, distant universe have less Lyman-alpha emission. This result raises several possibilities:

1) Galaxies are less star-forming at higher redshifts
2) Selections are missing galaxies with strong Lyman-alpha emission
3) Opaque regions filled with neutral hydrogen obscure Lyman-alpha
4) The galaxies that are brightest in Lyman-alpha are also massive and obscured by dust.

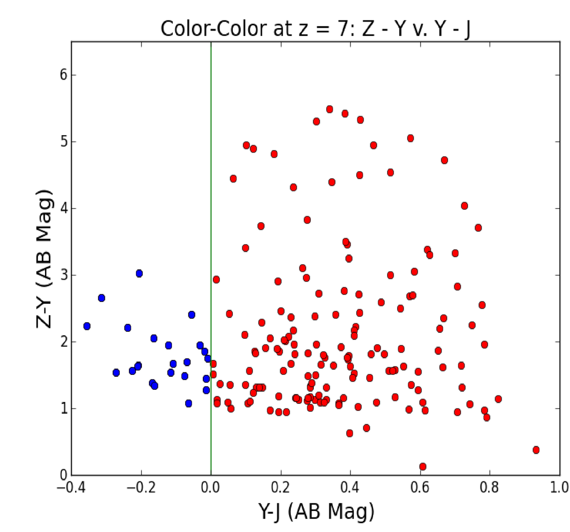
In order to expand the investigation of this trend, we must develop new ways to select galaxies with strong Lyman-alpha emission at high redshift.

Object Selection

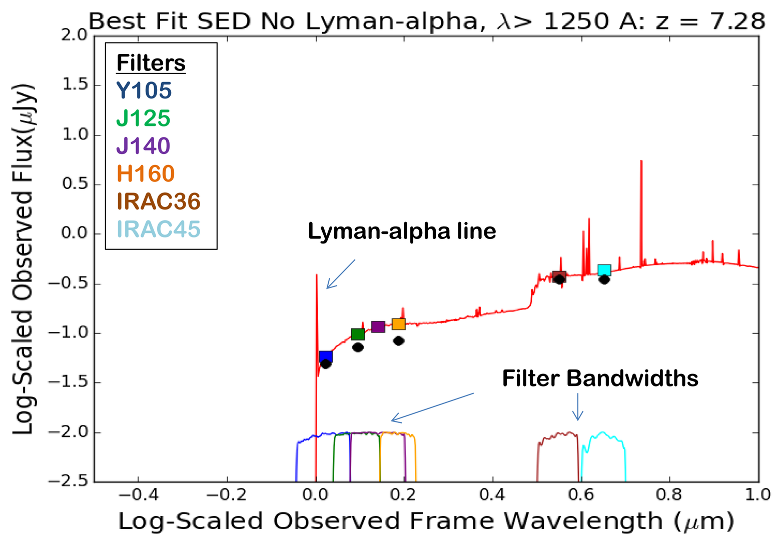


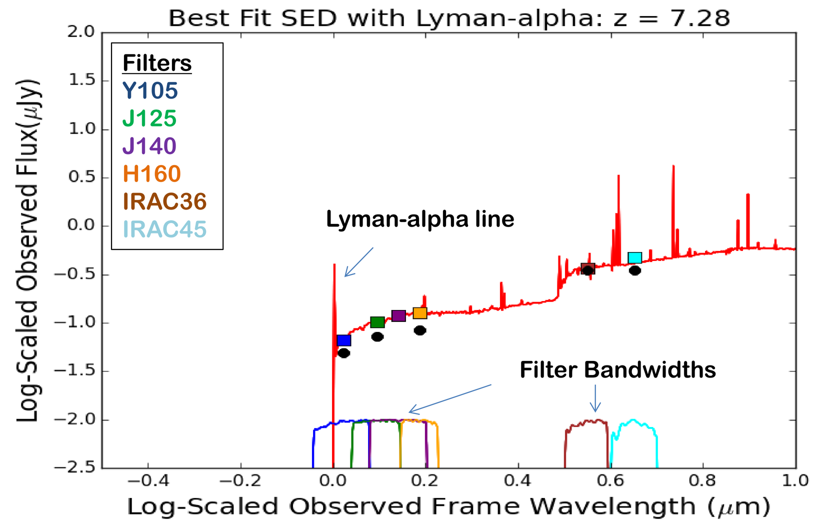
We first inspect a sample of galaxies that have robust photometric redshifts at z ~ 6-7. We use a color-color and color-magnitude with a color-color selection in the ACS z850, and WFC3 Y105 and J125 filters of the Hubble Space Telescope.

The z850, Y105, and J125 filters are centered at increasing wavelengths (energetically decreasing), and at these redshifts Lyman-alpha is a near the z850 and Y105 bands. One prediction would be that bluer colors indicate the presence of strong Lyman-alpha emission. **The distribution of colors at z=6 and z=7 do not reveal a significant blue population, directing us to explore an alternative selection method to find Lyman-alpha emitters.**



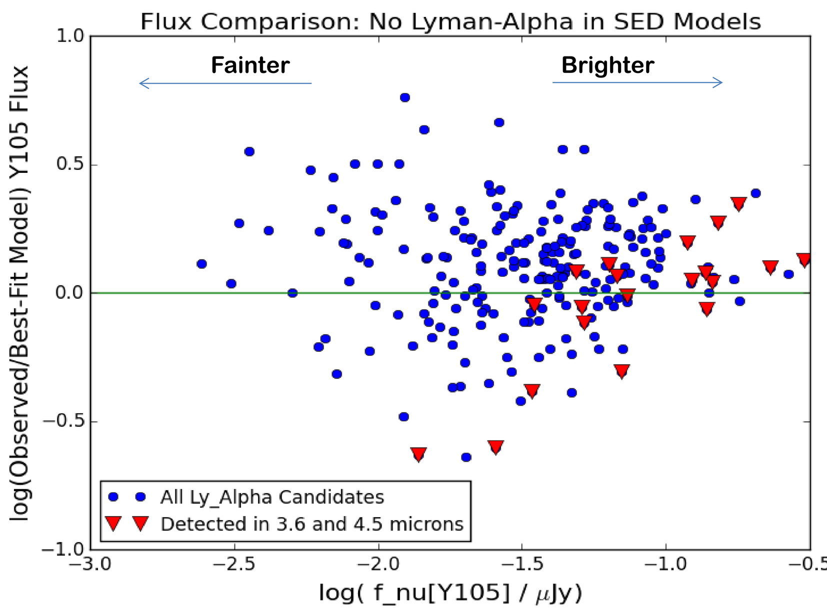
SED Fitting

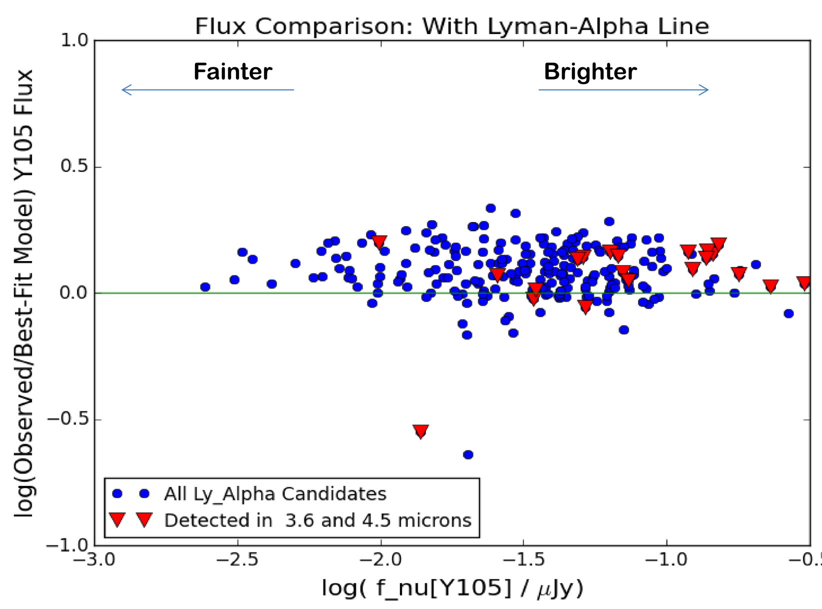




We applied spectral energy distribution (SED) fitting for all z=7 galaxies to infer their multi-wavelength SEDs and physical properties following Salmon et al. (2015). We calculate model fluxes (colored square) in their respective bands based off of the best-fit SED (red). The above plots show two versions of fits to one of the objects. The left SED ignored bands <1250 Angstroms in the fitting process, using the other bands to predict the amount of nebular emission. The right SED did fit to the band near the Lyman-alpha. The filter curves used to determine fluxes are shown below for reference.

Results





Left: the observed Y105 flux compared to the model flux when ignoring the Y105 band in the fitting process. Right: the observed Y105 flux compared to the model flux when fitting to the Y105 band. We find that faint Y105 galaxies under-produce the amount of Lyman-flux predicted from the other bands. However, UV bright galaxies match or over-predict Lyman-alpha, revealing a sample of candidate strong Lyman-alpha emitters. The plot to the right scatters around equivalence (log of the ratio equals 0), which is expected when fitting to the Y105 band. **We find that the Y105 flux excess can be used to search for strong Lyman-alpha emitting candidates.**

Acknowledgments

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