Lyα Emission from Green Peas: Circumgalactic Gas Density, Covering, and Kinematics

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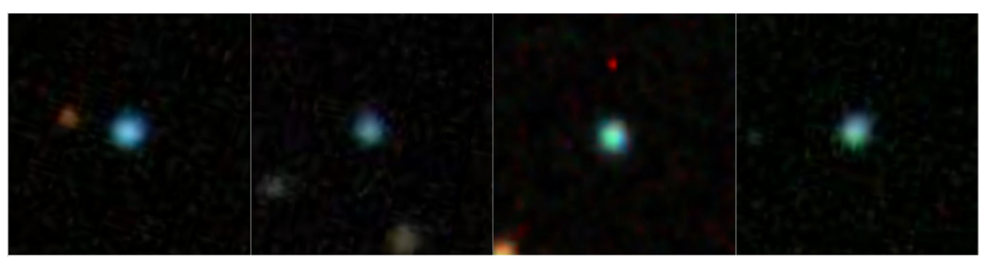
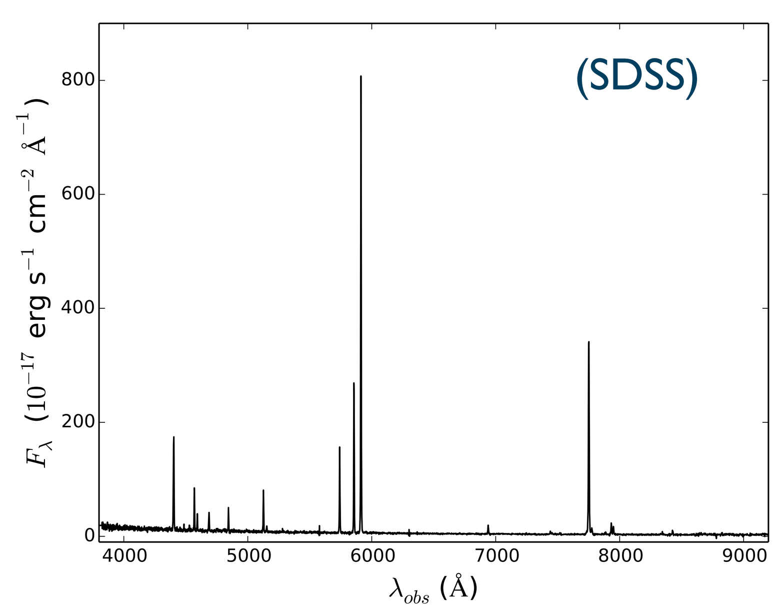
We report new HST/COS observations of the Lyα emission line and interstellar absorption lines in a sample of ten actively star-forming galaxies at z~0.2. Selected on the basis of high equivalent width emission lines, the sample, dubbed "Green Peas" make some of the best analogs for young galaxies in the early Universe. Because of the importance of Lyα for inferring properties of both galaxies and the intergalactic medium at early cosmic times, we aim to understand the processes that regulate Lyα output in young, metal poor starburst galaxies. *From the velocity structure of the Lyα line, we conclude that HI column density is the dominant factor determining its escape.*

1. What are the Green Peas, and what makes them good local laboratories?

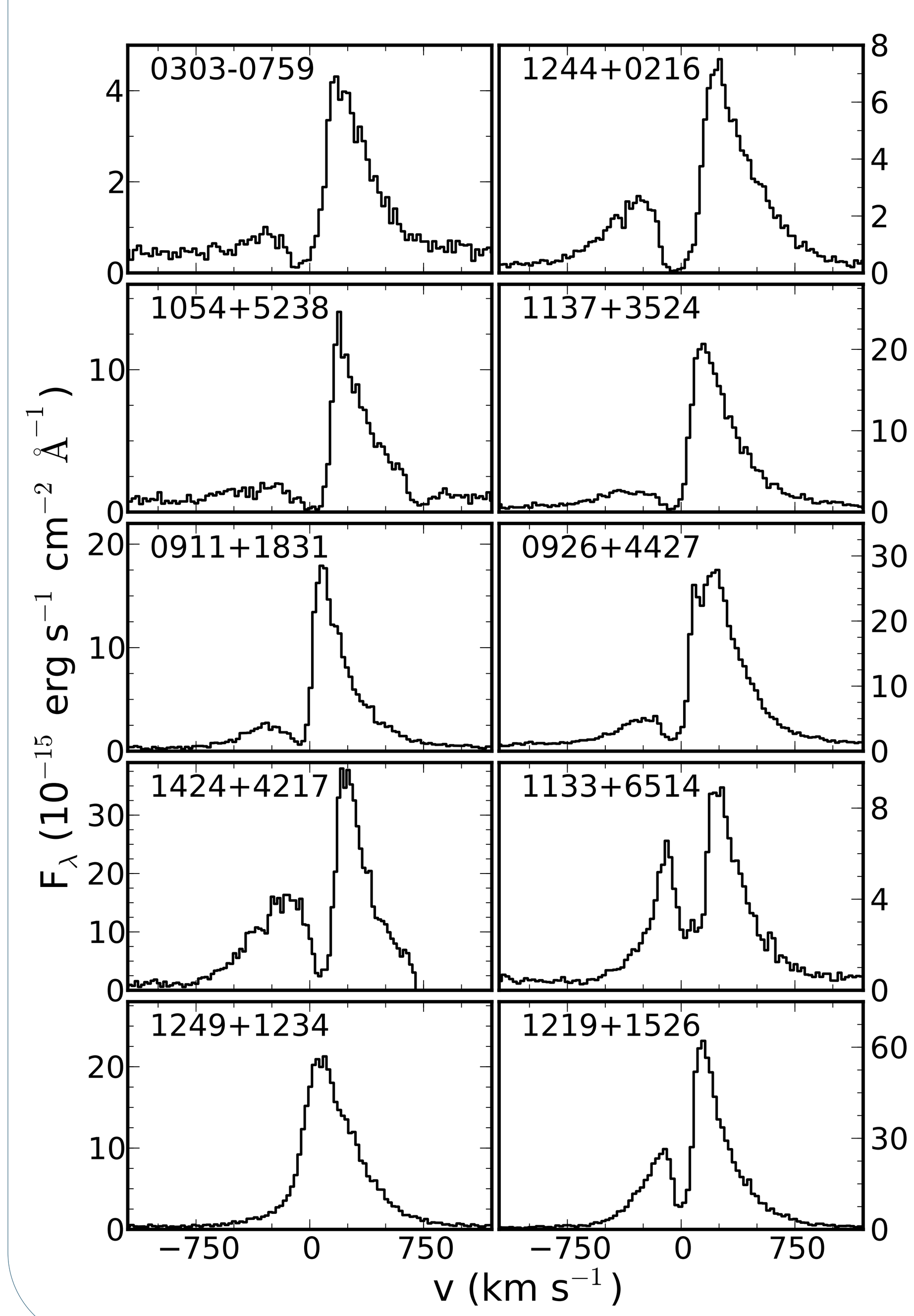


The SDSS/Galaxy Zoo discovered these unusual galaxies because of their compact sizes and green colors. This color results from high equivalent width [OIII] 4959, 5007 emission in the r band (Cardamone et al. 2009).



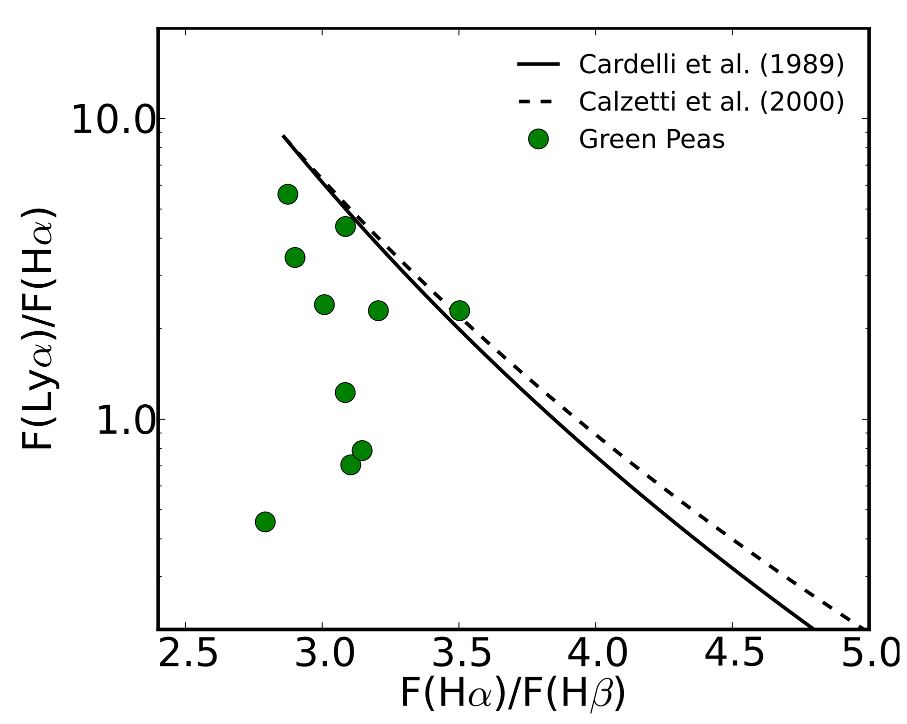
- Emission-line dominated spectra reveal low metallicity, highly ionized gas, and extremely low dust content.
- Equivalent widths are comparable to the inferred equivalent widths in emission-line contaminated photometry of z>4 galaxies (e.g. Shim et al. 2011; Smit et al. 2014).
- Like high-redshift galaxies, Green Peas fall below the local mass-metallicity relation and above the star-forming sequence on the BPT diagram.

2. COS Lyα Spectra of Green Peas



- 10 / 10 Green Peas show Lyα in emission.
- 9/10 Green Peas show double peaked profiles. **Blue emission peaks occur when the HI column density is low.** This feature is not commonly detectable at high-redshifts because of lower spectral resolution, low signal-to-noise ratios, and absorption by the Lyα forest

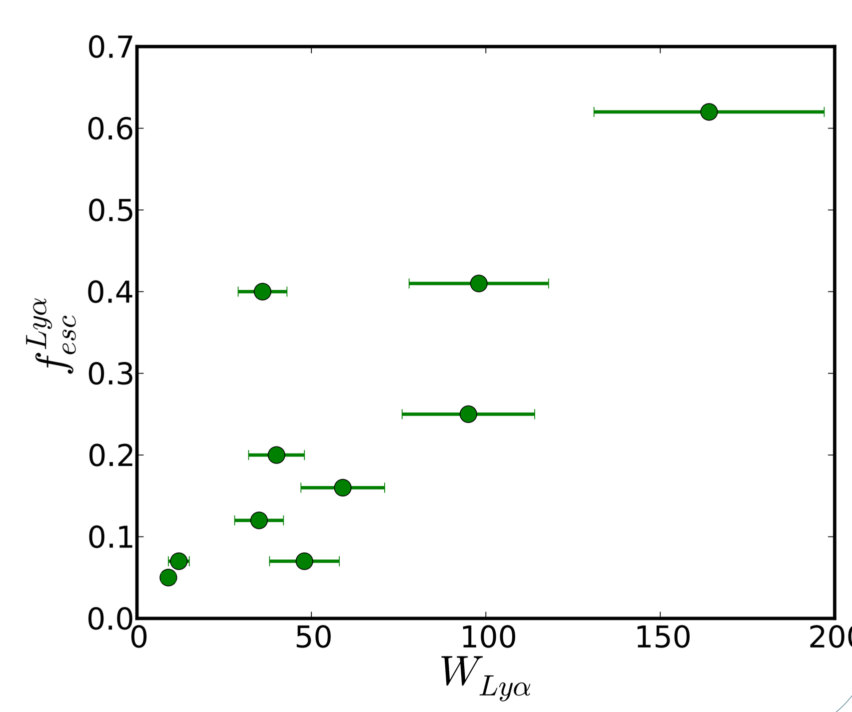
3. Quantifying Lyα output



(Left) The Lyα/Hα flux ratios of the Green Peas span a factor of 10, which is not easily explained by their dust content: the Hα/Hβ flux ratios occupy a small range of values consistent with E(B-V) ~ 0 - 0.1.

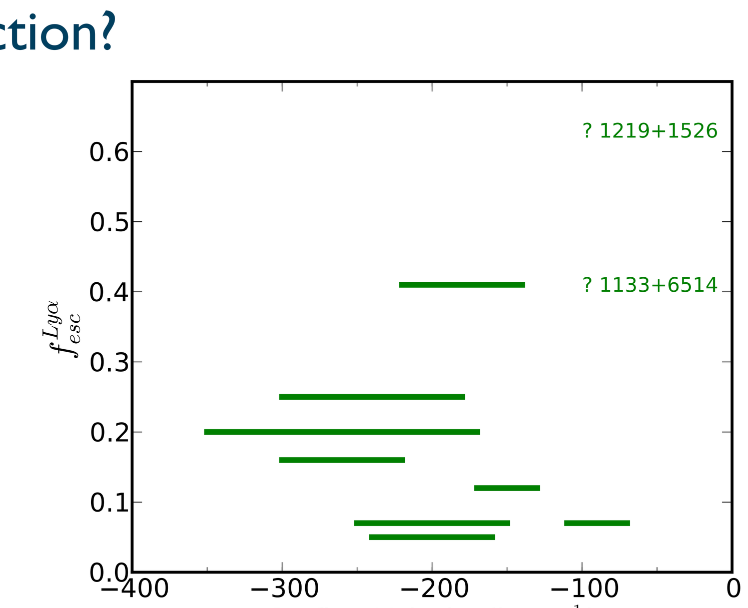
(Right) Like the Lyα/Hα flux ratio, the equivalent width of Lyα ($W_{Ly\alpha}$), and escape fraction ($f_{esc}^{Ly\alpha} = L_{obs}^{Ly\alpha} / C\ L_{int}^{H\alpha}$; with C~8-9) also span an order of magnitude.

Note: these Lyα fluxes count only the emission that entered the COS aperture.



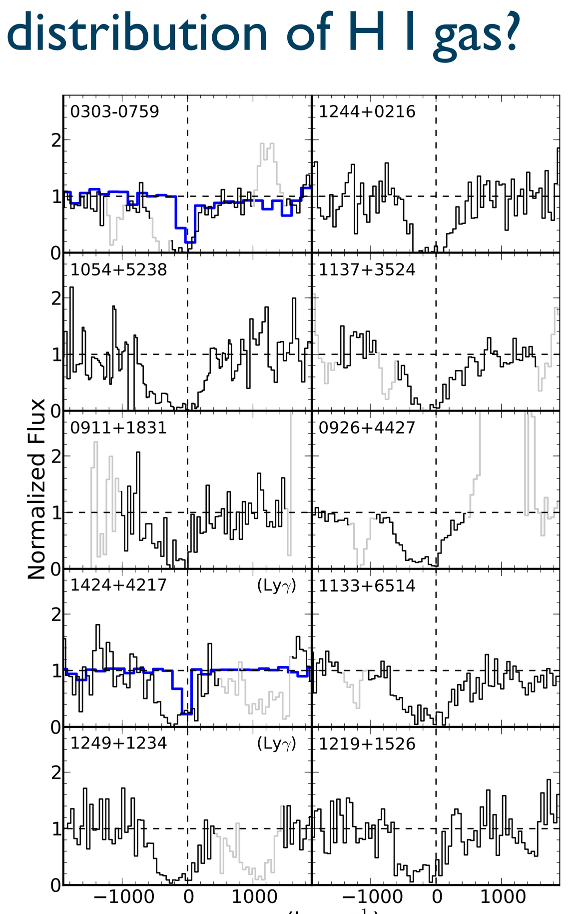
4. If not dust, then what is regulating the Lyα output of Green Peas?

(a) Does resonant scattering in neutral gas shift Lyα photons out of resonance with the ISM and allow a greater escape fraction?



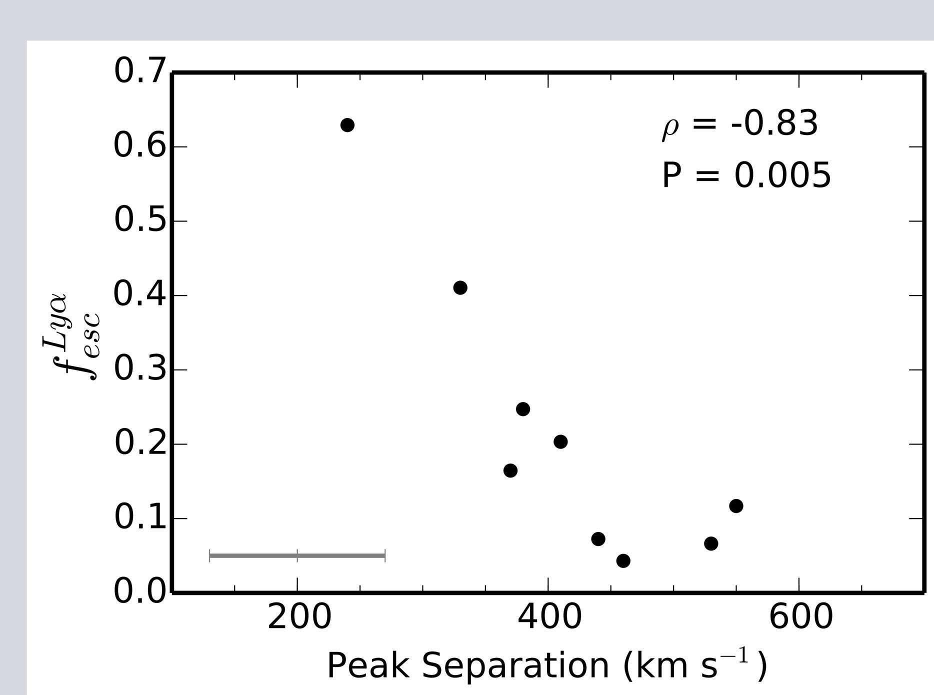
No. The Lyα escape fraction does not correlate with the outflow velocity measured in Si II and C II, which trace the cool component of the circumgalactic gas. However, two of the three highest $f_{esc}^{Ly\alpha}$ Green Peas show no detections in these ions.

(b) Does Lyα escape through holes in the distribution of H I gas?



No. The Green Pea spectra are opaque (or nearly so) to high velocities in their Lyman series absorption lines. (A model of the stellar component is shown in blue.)

(c) Does Lyα escape more easily when the HI column density is lower?



Yes. The velocity separation between the red and blue peaks correlates tightly with $f_{esc}^{Ly\alpha}$. Closer peak separation indicates lower HI column density, because Lyα photons scatter less and emerge closer to v~0. The closest peak separations may correspond with HI columns that are optically thin to hydrogen ionizing photons ($<10^{17}$ cm^{-2} ; Verhamme et al. 2014).

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