Spectroscopic Confirmation of Galaxies at $z = 6.844 - 7.213$: Demographics of Lyα Emission in $z \sim 7$ Galaxies

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One of the most outstanding questions in modern astronomy is when and how the cosmic reionization occurred. Since it requires a large number of ionizing photons, the process of reionization is closely related to an early phase of the cosmic structure formation history. Understanding the reionization process can be accomplished by studying the state of the IGM through estimates of the Lyα fraction, the fraction of Lyα emitters among dropout galaxies. Since neutral hydrogen in the IGM resonantly scatters Lyα photons, the Lyα fraction is expected to decrease at the epoch of reionization [1]. Searching for Lyα emission from samples of dropouts with available spectra at $4 < z < 6$, Stark et al. (2011) showed that the Lyα fraction does not decrease with redshift [2]. However, it is not yet clear if this trend continues at $z > 6$. To explore this, we require spectroscopy of $z \sim 7$ dropouts.

We performed Keck/DEIMOS spectroscopic observations of 11 z-dropout galaxies found in the SDF and GOODS-N fields [3,4]. An emission line is detected at 9500−10000 Å in the spectra of three objects. Since all the detected lines are singlet with a large positive weighted skewness, we conclude that the three objects are Lyα-emitting z-dropout galaxies at $z_{\rm spec} = 7.213$, 6.965, and 6.844. The $z = 7.213$ galaxy is confirmed by observations in two independent DEIMOS runs in 2010 and 2011 with three different spectroscopic configurations.

We then measure the Lyα fraction at $z \sim 7$. To reduce statistical uncertainties and possible effects of field-to-field variance, we combine our results with the z-dropout spectroscopic studies by other groups [5,6,7,8]. We find that the Lyα fraction drops from $z \sim 6$ to 7 in contrast to the reported increasing trend from $z \sim 4$ to 6. We also find that $X_{25}^{{\rm Ly}\alpha}$ drops more strongly in UV-faint galaxies than in UV-bright galaxies. These findings would suggest that the neutral fraction of the IGM significantly increases from $z \sim 6$ to 7, and that the increase is stronger around galaxies with fainter UV luminosities, which is consistent with inside-out reionization models where reionization proceeds from high- to low-density environments.

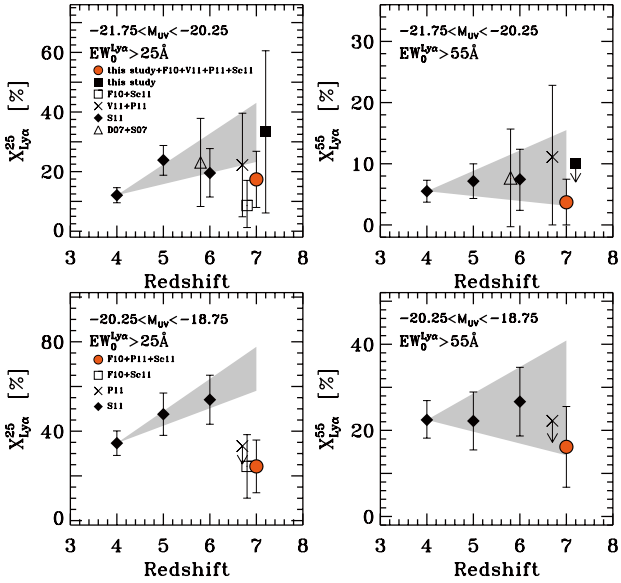

Figure 1: Evolution in the fraction of strong Lyα-emitting galaxies with $M_{\rm UV} \simeq -21.0$ (top panels) and $M_{\rm UV} \simeq -19.5$ (bottom panels) over $4 < z < 7$. The left panels show the fraction of galaxies with EW larger than 25 Å, while the right panels show the fraction of those with EW larger than 55 Å. The red filled circle is the composite result, and the shaded area is derived by extrapolating the trend seen in lower redshifts to $z \sim 7$. For details, see [4].

References

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