



Spectroscopic Confirmation of Three z-Dropout Galaxies at $z = 6.844 - 7.213$: Demographics of Lyman-Alpha Emission in $z \sim 7$ Galaxies

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We present the results of our ultra-deep Keck/DEIMOS spectroscopy of z-dropout galaxies in the SDF and GOODS-N. For 3 out of 11 objects, we detect an emission line at $\sim 1\mu\text{m}$ with a signal-to-noise ratio of ~ 10 . The lines show asymmetric profiles with high weighted skewness values, consistent with being Ly α , yielding redshifts of $z=7.213$, 6.965, and 6.844. Specifically, we confirm the $z=7.213$ object in two independent DEIMOS runs with different spectroscopic configurations. The $z=6.965$ object is a known Ly α emitter, IOK-1, for which our improved spectrum at a higher resolution yields a robust skewness measurement. The three z-dropouts have Ly α fluxes of 3×10^{-17} erg $\text{s}^{-1} \text{cm}^{-2}$ and rest-frame equivalent widths $\text{EW}_0^{\text{Ly}\alpha} = 33\text{-}43\text{\AA}$. Based on the largest spectroscopic sample of 43 z-dropouts that is the combination of our and previous data, we find that the fraction of Ly α -emitting galaxies ($\text{EW}_0^{\text{Ly}\alpha} > 25\text{\AA}$) is low at $z \sim 7$; $17 \pm 10\%$ and $24 \pm 12\%$ for bright ($M_{\text{UV}} \sim -21$) and faint ($M_{\text{UV}} \sim -19.5$) galaxies, respectively. The fractions of Ly α -emitting galaxies drop from $z \sim 6$ to 7 and the amplitude of the drop is larger for faint galaxies than for bright galaxies. These two pieces of evidence would indicate that the neutral hydrogen fraction of the IGM increases from $z \sim 6$ to 7, and that the reionization proceeds from high- to low-density environments, as suggested by an inside-out reionization model.

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