

Does reionization cause the rapid drop in galactic $\text{Ly}\alpha$ emission at $z \geq 6$?

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Abstract

The large cross-section of the $\text{Ly}\alpha$ line makes it a sensitive probe of the ionization state of the intergalactic medium (IGM). We present the most complete study to date of the IGM $\text{Ly}\alpha$ opacity, and its application to the redshift evolution of the ‘ $\text{Ly}\alpha$ fraction’, i.e. the fraction of color-selected galaxies with a detectable $\text{Ly}\alpha$ emission line. We use a tiered approach, which combines large-scale semi-numeric simulations of reionization with moderate-scale hydrodynamic simulations of the ionized IGM. This allows us to simultaneously account for evolution in both: (i) the opacity from an incomplete (patchy) reionization, parameterized by the filling factor of ionized regions, Q_{HII} ; and (ii) the opacity from self-shielded systems in the ionized IGM, parameterized by the average photo-ionization rate inside HII regions, Γ . In contrast to recent empirical models, attenuation from patchy reionization has a unimodal distribution along different sightlines, while attenuation from self-shielded systems is more bimodal. We quantify the average IGM transmission in our (Q_{HII}, Γ) parameter space, which can easily be used to interpret new data sets. Our new, improved models highly disfavor an evolution in Γ as the sole driver of a large change in IGM opacity. Using current observations, we predict that the $\text{Ly}\alpha$ fraction cannot drop by more than a factor of ≈ 2 with IGM attenuation alone, even for HII filling factors as low as $Q_{\text{HII}} \geq 0.1$. Larger changes in the $\text{Ly}\alpha$ fraction could result from a co-evolution with galaxy properties. Marginalizing over Γ , we find that current observations constrain $Q_{\text{HII}}(z \approx 7) \leq 0.6$, at a 68% confidence level (C.L.). However, all of our parameter space is consistent with observations at 95% C.L., highlighting the need for larger observational samples at $z \geq 6$.