Does reionization cause the rapid drop in galactic Lyα emission at $z \geq 6$?

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Abstract

The large cross-section of the Lyα 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 Lyα opacity, and its application to the redshift evolution of the 'Lyα fraction', i.e. the fraction of color-selected galaxies with a detectable Lyα 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, $Q_{\rm HII}$; 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 ($Q_{\rm HII}$, 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 Lyα fraction cannot drop by more than a factor of ≈ 2 with IGM attenuation alone, even for HII filling factors as low as $Q_{\rm HII} \geq 0.1$. Larger changes in the Lyα fraction could result from a co-evolution with galaxy properties. Marginalizing over Γ, we find that current observations constrain $Q_{\rm HII}(z \approx 7) \leq 0.6$, 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 $z \geq 6$.