The Damping Wing in $z \sim 5 - 6$ Quasars

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1 Background

The Epoch of Reionization (EoR) is the final phase transition of the universe as the diffuse, neutral intergalactic medium (IGM) is ionized by the first generation of galaxies. Observations of this era are limited. The main constraints on the timing of the EoR come from measurements of the optical depth from the cosmic microwave background (CMB). Recent measurements place $\tau \sim 0.05$, which corresponds to a reionization midpoint of $z_r \sim 7.5$, depending on the exact ionization history used (Planck Collaboration et al., 2018). Since the form of the ionization history is not known, this allows for various reionization scenarios, but most plausible scenarios place the end of reionization to be prior to $z \sim 6$.

In a related problem, the Lyα optical depth of individual quasars is known to show a large degree of spatial fluctuation, signficantly larger than expected from density fluctuations alone (e.g. Becker et al., 2015). Typical explanations for this problem either make use of a fluctuating UV background (Chardin et al., 2017) or

Our project will attempt to either measure or place an upper limit on the bulk neutral fraction at $z < 6$. Since the optical depth for the Lyα transmission is high, a neutral fraction of only $\sim 10^{-4}$ is necessary to completely block transmission. Therefore, it is impossible to naively identify a region with no Lyα transmission as being caused by a neutral hydrogen cloud or a region of slight residual netural fraction.

2 Description of Project

We will attempt to determine if certain dark gaps in $z \sim 5 - 6$ quasar spectra are caused by neutral clouds of hydrogen gas instead of a residual neutral fraction $\gtrsim 10^{-4}$. We will be relying upon a technique developed by Malloy & Lidz (2015) which uses the damping wing to distinguish between the two scenarios. Since significant absorption far from line center (i.e. $\Delta v \sim 300$km/s) occurs only when the neutral fraction of the cloud is close to unity, one can detect a "wing" of transmission instead of a sharp recovery to mean flux (Figure 4 Malloy & Lidz, 2015). Such a feature cannot be detected in a single spectra — however, by stacking several spectra together, we hope to be able to measure the damping wing feature.

We plan to primarily use the set of $z \sim 5.7 - 6.5$ spectra from Eilers et al. (2018). If necessary, we will also use older spectra from Fan et al. (2006).

References

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