Charting Molecular Gas Through Cosmological Time: Present Results and Future Directions

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Molecular gas, observed through tracers such as CO rotational transitions, is a vital component of galactic evolution and star formation. Recent detections of the CO molecule in massive galaxies at redshifts as high as $z = 6.42$ have demonstrated its existence in the early Universe, and have motivated its use as a means of exploring large-scale structure and as a probe of galaxy evolution in the early Universe. But many questions about molecular gas and the evolution of galaxies in the early Universe still remain: its distribution at high redshift understood is so poorly that theoretical models of the mean abundance of CO for $z \gtrsim 2$ span orders of magnitude. Direct detection of molecular gas in galaxies at these redshifts (with instruments like the VLA) have only found the largest and most luminous of galaxies at these redshifts (typically containing $10^{10} M_\odot$ of molecular gas and star formation rates of $100 M_\odot \mathrm{yr}^{-1}$), whereas the bulk of the molecular gas is expected to be in the unseen masses of smaller galaxies ($M_{gas} \sim 10^8 M_\odot$; $SFR \sim 1 M_\odot$ yr^{-1}). While difficult to detect individually, these smaller galaxies are likely detectable as an integrated ensemble with the technique of "intensity mapping". This technique, similar to those employed by HI epoch of reionization experiments, utilizes measurements of different 3D Fourier modes to construct a power spectrum.

The Sunyaev-Zel'dovich Array (SZA) offers a unique opportunity to begin exploring molecular gas at high redshift through intensity mapping. The SZA, an 8-element closely packed array is capable of observing over an 8 GHz range centered at 31 GHz, with a 240 channel XF correlator, and is capable of observing at $z = 5.5 - 7.5$ with the $J = 2 \rightarrow 1$ transition and $z = 2.3 - 3.3$ with the $J = 1 \rightarrow 0$ transition.

We present a power spectrum from of our current search for CO at $z \sim 3$, which utilizes two datasets. The first dataset arises from a survey of 44 fields (20 hours integration time a piece), originally focused on arcminute-scale features in the CMB. The second from recent (and ongoing) 300 hour observation of the GOODS-North field, a target rich in observational data at many wavelengths ripe with opportunities for cross-correlation. Combined, these two datasets offer complementary perspectives (one wide and shallow, the other deep but narrow) to explore systematics and ensure fidelity in our measurements. In addition to presenting current constraints on the CO power spectrum, we also present tools and techniques developed for identifying and removing systematics and other contaminants to our results. We will discuss current design ideas for the Dense Array for Cosmological Transitions (DACOTA), an instrument that will be focused on exploring the abundance of CO at $z \sim 6 - 10$.