CO Intensity Mapping: First Constraints on the Molecular Gas Power Spectrum at Redshift 3

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In the nearby universe, the formation of stars and the abundance of the molecular gas that fuels star formation are tightly linked. However, in the first few billion years of cosmic history the bulk of the stellar mass of the universe was assembled under conditions that do not closely resemble those seen nearby. The transformation of molecular gas into stars can be expected to proceed differently under early universe conditions – higher density and temperature, lower metallicity, and increased frequency of dynamical interactions.

While the star formation history of the universe is now very well studied, using many techniques derived from many different wavelengths, the same cannot be said for the formation and distribution of molecular gas. This is largely due to the difficulty of observing the molecular interstellar medium (ISM) in distant galaxies. Molecular gas, as traced by redshifted emission lines of carbon monoxide at centimeter and millimeter wavelengths, can only be studied in the most massive reservoirs with current instruments. A more complete picture, in which the growth of the molecular ISM is observable across cosmic time from a large sample of objects, is needed to complement the star formation history of the universe and inform our galaxy formation models. The tool of intensity mapping, which characterizes the aggregated signal from thousands of individually undetected galaxies, can provide this missing information.

In this talk I will describe a program using the Sunyaev-Zel'dovich Array (SZA), the 8x3.5m subset of the Combined Array for Research in Millimeter-wave Astronomy, to make the first measurements of the CO power spectrum at z = 2.3-3.3. In the first phase of this program (G. K. Keating et al., 2015, submitted) we have used archival SZA data to place an upper limit on the CO power spectrum and exclude optimistic models of the molecular gas distribution. Subsequent observations, completed in 2015, extend our sensitivity by an order of magnitude and will reach the predictions of several more models, as well as allow cross correlation with optical survey data. I will describe the state of these data and the future of our program to detect and characterize the growth of molecular gas in the early universe.