Exploring the Obstacles of CO EoR Measurements: An Archival Analysis of SZA Data

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The Epoch of Reionization (EoR), a time in which the infant Universe transformed a sea of raw, neutral gas into the building blocks of galaxies observed today, is currently an area of active research. Instruments such as PAPER, MWA and LOFAR are exploring this era by measuring the disappearance of neutral hydrogen gas during this time. These instruments, rather than imaging individual bubbles of ionized gas, are making use of a non-imaging technique known as intensity mapping, where the signal from many unresolved faint structures in a particular spatial distribution (i.e. k-mode) are all summed together.

While most observations and instruments exploring the EoR have used the HI 21-cm transition, other transitions like the CO rotational transitions offer additional opportunities to probe this era. Theoretical expectations of the CO distribution place the expected signal strength of approximately 1 microKelvin, much weaker than expected contributions of diffuse Galactic emission and extragalactic radio sources. Surveying the Universe for such a weak signal will require hundreds of hours of integration and high-fidelity tools and analysis to prevent contamination by stronger sources of radiation.

The Sunyaev-Zeldovich Array (SZA), an 8-element array originally designed to measure inverse Compton scattering of CMB photons by hot gas in massive galaxy clusters, offers a unique opportunity to begin exploring the foregrounds and systematics confronting EoR CO observations. The SZA is capable of observing over an 8 GHz range centered at 31 GHz, with a 272 channel XF correlator. Using 500 days of archival data spread across 44 individual fields, we explore the distribution of CO (through the J=2-1 transition) from redshift z=5.5-7.5. We establish upper bounds for CO matter power spectrum for this redshift range, and present the tools and techniques used for converting data normally used for aperture synthesis imaging into non-imaging cosmological measurements. In particular, we focus on measurements of gains and bandpass stability, foreground contributions and other sources of systematic error.