A Novel Approach to Detecting the 21cm EoR Power Spectrum

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Derivation of the power spectrum of the large scale structure in the neutral gas during cosmic reionization ($z \sim 6$ to 10), using the HI 21cm line, is complicated by the extremely strong foreground continuum signal, some four to five orders of magnitude stronger than the HI line signal. Techniques to extract the line signal from the measurements have focused on two areas. First is the foreground 'removal' technique, employed by eg. the LOFAR team, in which wide field calibration and imaging techniques are used to derive, and subtract, the continuum emission, as well as smooth curve spectral fitting to remove residual diffuse continuum emission. Second is the 'avoidance' technique, employed by the PAPER and HERA teams, in which the spectral structure of the continuum signal in the visibilities due to the chromatic response of the interferometer is avoided through a power spectral calculation along the frequency axis (the 'delay spectrum'), ie. the low k modes are corrupted, but the high k modes may be free of continuum emission, depending on baseline length. There are also hybrid techniques being considered by eg. the MWA and HERA teams, where the strongest continuum sources are removed prior to the delay spectrum calculation. In both cases, accurate bandpass calibration is required to avoid coupling the strong continuum signal to the line signal.

We will present an alternative technique using measurements of the closure phase spectra for the interferometer. Closure quantities have long been employed in interferometry as a powerful technique to obtain fundamental information on the sky brightness distribution in instances when accurate visibility phase and amplitude calibration is difficult or impossible. Applications range from low frequency interferometry, where the ionosphere adversely affects the visibilities, to optical interferometry, where tropospheric seeing is the challenge, to recent submm VLBI, where tropospheric phase stability can be problematic.

We will show that spectra of the closure phase can be used to derive the power spectral statistics of the HI 21cm emission, even with no calibration applied. A variant of the delay spectrum approach is used to separate the broad band continuum emission from the line signal in the closure phase power spectra. The technique is described in Thyagarajan, Carilli, & Nikolic (2018, Phys. Rev. Letters, 120, 1301), and Carilli et al. (2018, Radio Science, 53, 6). First results from the HERA array will be presented.

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