Shedding light on foregrounds with new MWA and PAPER data

Daniel C. Jacobs and Judd D. Bowman
School of Earth and Space Exploration, Arizona State University, AZ

Significant effort has recently been turned to the problem of detecting and characterizing intergalactic hydrogen prior to its complete ionization by stars, occurring sometime before t=950Ma (z=6). The distribution of HI, visible in redshifted 21cm radio emission, is one of the few observables into the onset of non-linear structure leading to the birth of the first stars and galaxies. Before it was ionized by stellar UV radiation, HI was found throughout the universe, roughly tracing out the underlying matter distribution and temperature. HI 21cm emission from this epoch ($6 < z < 12$) is redshifted into the VHF radio band ($100 < f < 200$ MHz) and with a observer frequency depending on redshift/distance provides a fully three dimensional view. The emission is expected to have surface brightness of ∼25mK with a non-gaussian distribution and most power occurring on scales of 10cMpc.

One of the most difficult aspects of this observation are the comparatively bright foregrounds. Smooth galactic emission and confusion limited point source populations amount to a foreground signal that is five orders of magnitude brighter than the HI background. Early measurements by GMRT, LOFAR, MWA and PAPER have begun to measure, understand, and subtract foregrounds with various measures of success. Meanwhile, several independent analyses have described the unique behavior of wide-field foregrounds in 3D power spectrum space, a previously unexplored aspect of spectral line imaging. The identification of the power spectrum "wedge" and corresponding EoR "window", where foregrounds are thought to be minimal, has helped crystalize the tradeoffs between sensitivity and foreground contamination but has been informed by only a small amount of data.

Here we describe how data from PAPER and MWA have significantly tightened our constraints on bright foregrounds, and through comparison, identified some of the most likely sources of error in foreground removal steps. In addition we present early results of an exploration of the redshift and spatial dependence of fainter foreground components identified in the deep PAPER data which has so far given the tightest constraints. Comparing with new MWA observations we seek to separate possible faint foreground contamination from equally likely systematic corruption.