Sample Variance in Realistic 21 cm EoR Simulations

Adam E. Lanman[1] and Jonathan C. Pober[2]

[1] adam_lanman@brown.edu
[2] jonathan_pober@brown.edu

Redshifted 21 cm emissions offer a faint view into an otherwise dark period of the universe's history – the so-called *Cosmic Dawn*, when the first ionizing sources formed and began heating and reionizing the intergalactic medium. A successful measurement of the 21 cm power spectrum from this time would provide a three-dimensional picture of large-scale structure formation and insight into the astrophysics behind early star and galaxy formation. This is the goal of current experiments like the Hydrogen Epoch of Reionization Array (HERA) and the Murchison Widefield Array's (MWA) EoR program. Setting constraints on EoR models will require an understanding of how sample variance relates to observation and analysis strategies. This is especially important for delay-spectrum methods, which rely heavily on baseline redundancy, and so sample fewer independent k-modes.

FHD (Fast Holographic Deconvolution) is a software framework built for calibration, imaging, and foreground subtraction with MWA data, which can be readily applied to other instruments. The FHD imaging algorithm, a variant of A-projection and forward modeling, uses the primary beam of the antenna to both grid data and simulate foregrounds. Beginning with a sky model and a set of instrument parameters, FHD generates a set of model visibilities by convolving the antenna response with the sky model in the uv plane. Thus far, FHD has been used to simulate diffuse emission from the Global Sky Model, point sources from the GLEAM catalog, and EoR models derived from 21cmFAST simulations.

The EoR model is obtained by slicing a 21cmFAST coeval cube at linear steps in redshift and tiling the slices across the sky. This produces a box of healpix maps vs. redshift, which can then be interpolated to the frequencies observed by a given instrument. Though the slices are taken of a coeval cube, each is taken from a different part of the cube, ensuring that we're probing independent structures at each redshift. This produces a realistic non-Gaussian EoR signal for instrument simulation. Kittiwisit et al. recently used this interpolation method to estimate the sample variance of 1-point statistics (Kittiwisit et al., 2017, in prep), finding that in some cases sample variance is more significant than variance due to thermal noise. My talk will cover estimates of power spectrum sample variance from FHD simulations of an interpolated EoR model with zero foreground contamination with HERA19 and MWA128. I will also compare delay-spectrum to sky-reconstruction power spectrum analysis approaches they relate to sample variance by comparing the results of the εppsilon and PAPER analysis pipelines.