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THE EFFECT OF ANTENNA BEAM VARIATION ON REDUNDANT CALIBRATION AND POWER SPECTRUM ESTIMATION WITH HERA

Honggeun Kim, Jacqueline N. Hewitt, Eloy de Lera Acedo, Scott B. C. Dynes, Bang D. Nhan, Joshua S. Dillon representing the HERA collaboration

ABSTRACT

Detecting hydrogen 21 cm signals from the Cosmic Dawn and epoch of reionization (EoR) is challenging because of foregrounds which are about 4-5 orders of magnitude brighter. In power spectrum analysis, spectral and spatial smoothness of foregrounds makes it possible to separate EoR signals from foregrounds, and precise calibration is necessary to achieve the foreground separation. One way to calibrate data with high precision is redundant calibration which uses redundancy of baselines without dependence on sky models. However, redundant calibration assumes perfect redundancy of the system, and calibration errors due to non-redundancy can propagate to foreground contamination of power spectra.

Field measurements with HERA show that the feed position and tilt angle of each antenna vary in time, which is a possible source of non-redundancy. We present results of simulations of HERA observations, calibration, and power spectrum estimation, incorporating beam variations caused by feed motion. These simulation show the impact of beam variations on EoR power spectrum measurements, and can be used to set tolerances for feed positioning.