Can We Calibrate Out the Wedge with HERA and its Successors?

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The Hydrogen Epoch of Reionization Array (HERA) is an instrument dedicated to measuring 21 cm emission from the intergalactic medium (IGM) during cosmic reionization ($z = 6$–12) and earlier stages of our Cosmic Dawn ($z \sim 30$). HERA expects to help us learn about how early stars and black holes heated and ionized the IGM by characterizing the evolution of the 21 cm power spectrum, and more speculatively, by producing three dimensional maps of the 21 cm brightness temperature field.

To support these efforts, HERA has developed a hybrid approach to calibration that incorporates both sky-based and redundancy-based features, modeling instrument and sky systematic uncertainties to minimize their impact on analysis. HERA's antenna configuration, which offers repeated sampling of spatial Fourier modes, has been a powerful tool for this. In the near term, we hope to use HERA's compact, staggered core to instantaneously solve for degrees of freedom in the HERA antenna beams.

HERA's dense grid also provides numerous interferometric baselines that sample identical angular modes at different frequencies. Using redundancy along the frequency axis is experimental, but it provides a natural framework for determining the spectral evolution of an instrument and for constraining the amount of spectral structure that can be absorbed into a calibration model. However, to be effective, these calibration models must be informed by sky-based calibration results in order to parametrize them effectively.

In this talk, we assess the current state of calibration and foreground mitigation in HERA data and examine how these are supported by the design of the HERA instrument. We offer some lessons garnered from HERA and discuss near-term and more speculative analysis techniques that might help control how smooth-spectrum foregrounds interact with an inherently chromatic instrumental response.