# Beam Chromaticity of the EDGES Low-Band Blade Dipole

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The sensitivity in the detection of the redshifted global 21cm signal is limited by systematic errors due to astronomical foregrounds and the instrument. Global 21cm instruments typically use a single radio antenna coupled to a radio spectrometer to accurately measure the sky-averaged spectrum. One potential source of systematic error is frequency-dependence of the antenna beam pattern. Chromatic antenna beams couple angular structures in Galactic foreground emission to spectral structures that may not be fit by foreground models based on synchrotron and free-free emission. Chromatic changes of the order of only 0.1% in the primary beam of the antenna can introduce spectral features that would limit the detection sensitivity.

The response of the Experiment to Detect the Global EoR Signature (EDGES) antenna is a leading source of uncertainty in the results reported in Bowman et al. (2018). We simulate the low-band blade (40 - 100 MHz) dipole antenna using three different electromagnetic (EM) solvers to assess the antenna response at different frequencies. We validate the results by carrying out comparisons between the models and find that simulations of simplified model of the antenna over an infinite perfectly conducting ground plane, with one exception, robust to changes of code or algorithm. To simulate a finite ground plane and actual soil below the antenna, we use the MOM solver techniques and obtain the beam patterns. To quantitatively assess the effectiveness of each of the beam solutions, we convolve them with the Haslam 408 MHz sky map scaled to the observing frequencies (40-100 MHz) and compare simulated spectra with the sky data collected using the EDGES low-band systems in Western Australia. The simulated data product from an early EDGES-Low iteration which had a 10 m x 10 m ground plane operating at 55 to 97MHz, results in a residual of $230^{+48}_{-41}$ mK. A similar analysis of the 30 m x 30 m sawtooth ground plane used for the primary measurements in Bowman et al. (2018) finds an RMS reduced by a factor of 2.5 ( 89 mK). This finding reinforces the conclusion that such a ground plane reduces spectral distortion. We show that the simulated spectra matches the actual data with 4%, a limitation of net accuracy of the sky and beam model. We observe that spectral structures match qualitatively, suggesting chromaticity imposed by the beam is being represented. Making further use of this robust beam model we explore the impact of soil properties, finding that soil conductivity of 0.02 S/m and relative permittivity of 3.5 yield good agreement between simulated spectra and observations, consistent with the soil properties reported by Sutinjo et al. (2015) for the Murchison Radio-astronomy Observatory, where EDGES is located.