

An External Calibrator for Hydrogen Observatories (ECHO)

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A new generation of radio arrays is being developed that use large numbers of low-cost elements, such as phased tiles of dipole antennas, to map Hydrogen at very high redshift. These maps are three dimensional tracers of matter and energy when the universe was only 400,000 years old and cover scales –Mpc to Gpc– much larger than previously possible. One challenge is in calibrating the phased arrays of dipoles at a level sufficient for precise spectral imaging. In particular, precise calibration of the primary beams of these dipole arrays has been found to be crucial to analysis of observations from the Murchison Widefield Array (MWA), the Precision Array for Probing the Epoch of Reionization (PAPER), the LOw Frequency ARray (LO-FAR), and the upcoming Hydrogen Epoch of Reionization Array (HERA). Beam calibration of low frequency dipole arrays (80-300 MHz) poses several complications compared to traditional, steerable, dish antennas. The goal of the External Calibrator for HI Observatories (ECHO) is to map the primary beam response using a drone-mounted transmitter. Accurate maps of the primary beam have been found to be crucial at multiple stages in Epoch of Reionization analysis, but have historically been difficult to obtain. Other methods either rely on external sources of radiation such as the ORBCOMM satellite constellation, extragalactic point sources, or lab testing in anechoic chambers. ECHO aims to provide a direct measurement with a system where all parameters are under the experimenter’s control. ECHO utilizes an autonomous drone with an onboard tunable oscillator transmitted by a broadband bow-tie dipole antenna. To measure the beam, the drone is flown along a pre-programmed flight path designed to measure the antenna’s response with a uniform sampling. As a test of this method we measured the beams of the reference dipoles used in the ORBCOMM beam mapping setup described in Neben et al. (2015, Radio Sci.,v. 50 i. 7, p. 614). Here we present the results of these tests.