Feedback Calibration of the MOFF Correlator

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Proposed radio arrays to probe the Epoch of Reionization and dark energy through HI 21 cm measurements will require compact arrays with tens of thousands of antenna elements. The computation requirements of traditional XF or FX correlators for these arrays would easily reach the peta-flop regime, making the correlator a dominant cost. The MOFF (Modular Optimal Frequency Fourier) correlator has been developed as an alternative method for fully correlating these large numbers of elements. The MOFF shares the computational advantages of direct imaging or FFT correlators while making no constraints on the antenna arrangement or type. A major concern for this new correlator design is the calibration. In traditional data processing, self-cal or related algorithms use visibilities to determine the calibration during postprocessing. The MOFF correlator does not form visibilities, but rather forms the image directly. In addition the crucial software holography step of the MOFF requires the antenna power patterns to be known in real time to use as the gridding kernel. Fortunately it is possible to determine the calibration by correlating pixels of the electric field image with the antenna signal - feeding the correlator output back to the input. Through simulations we demonstrate this feedback calibration method for several realistic example arrays in the presence of noise and extraneous sources. We show that the calibration converges as expected for compact large-N arrays characteristic of future 21 cm cosmology experiments, allowing the correlator to form high quality dirty electric field images at a fraction of the computational cost for traditional correlator methods.