Redundant and Non-Imaging Calibration of the Precision Array for Probing the Epoch of Reionization (PAPER)

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The Precision Array for Probing the Epoch of Reionization (PAPER) is a focused experiment aimed at detecting the spatial power spectrum of neutral hydrogen emission during the Epoch of Reionization (EoR). PAPER is an interferometer operating from 100 - 200 MHz at the site of the future Square Kilometre Array (SKA) site in South Africa. The PAPER antennas measure linear polarization and the correlator produces full-Stokes output. PAPER currently has 64 antennas and has just completed a 141-day science integration. An expansion to 128 antennas and another long observing campaign will be complete in late 2013.

In order to achieve maximum sensitivity to particular modes of the power spectrum, PAPER currently employs a highly redundant array configuration. This configuration samples the uv-plane extremely poorly by design, is not therefore particularly suited to standard self-calibration techniques. It has been known for many years (e.g Noordam & de Bruyn 1982), however, that instantaneous baseline redundancy allows a robust, fast and simple method for achieving relative gain and phase delay calibration between antennas. We consider the accuracy and long-term stability of the resulting calibration achieved with PAPER for Stokes I. Calibrating the leakage terms for the remaining Stokes parameters using only redundancy has proved challenging. We present a per-baseline method, appropriate for a non-imaging approach, to obtain the relative $x-y$ linear polarization delay and characterize remaining leakage terms. We finally demonstrate how the decoupling of the individual baselines' relative calibration from the determination of a sky model is used in conjunction with a delay-space CLEANing of the visibility to spectrum (Parsons & Backer 2009) to achieve high-dynamic-range suppression of smooth-spectrum foreground emission. This approach minimizes the effect of calibration errors on the estimation of the final EoR power spectrum.