HOLOGRAPHIC APERTURE ARRAY STATION CALIBRATION AT LOFAR

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Calibration of the instrumental beam former errors in aperture array stations as used in LOFAR and envisioned for the SKA is equivalent to adjusting the surface of dish antennas to maximize their gain. At LOFAR, we have traditionally determined these calibration coefficients by all-sky imaging using visibilities between antennas within each station. Although it generally works well, this procedure is sensitive to local interference, and requires long exposure times to average over errors due to necessarily incomplete all-sky source models. Data reduction takes several hours per individual antenna field, making e.g. monthly calibration unfeasible.

Dish antenna surfaces are often measured by antenna holography, where one antenna stares straight at a calibration source, while the antenna under investigation scans its beam across the source to measure its voltage beam pattern, which is subsequently Fourier transformed to yield the complex aperture illumination. We have adapted this method for aperture arrays and applied it to LOFAR.

While scanning the beam pattern can take many hours for dish antennas, aperture arrays can form hundreds of beams simultaneously, greatly reducing the time needed to do the observation. As will be demonstrated, the simultaneous observation of all pointings for a certain frequency greatly simplifies the data reduction. Calibrating all 71 LOFAR high band antenna fields at one frequency takes two times 30 seconds of integration time and only about a minute of data reduction, after which aperture maps for all fields are available for inspection. These maps are fantastic visual system diagnostics.