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Calibration and Sensitivity Determination of a LOFAR Station

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Sensitivity is one of the most important characteristics of a radio telescope. However for modern radio telescopes such as LOFAR, determining the sensitivity is complicated by the calibration challenges such as: at the lowest frequencies the primary beam has a wide field-of-view that includes the full sky, which means reference models are not simple point sources, but extended fields; and there is no on-line temperature reference source to provide system temperature measurements. In addition to the difficulties in calibration, there is no clear definition of sensitivity for off-boresight, polarimetric antennas.

Recently, a definition of antenna sensitivity that includes the polarized nature of radio antennas has been introduced [1]. It takes into consideration the fact that the two polarized channels vary independently away from boresight:

$$S^{(SEFD)} = J^{-1}NJ \tag{1}$$

where $S^{(SEFD)}$ is a matrix representing the polarimetric antenna sensitivity, J is the complex Jones matrix and N is the polarimetric, system noise temperature. Since the Jones matrix typically goes to zero for at least one of the polarization channels off-boresight, the sensitivity goes to infinity. Thus for fixed-mount telescopes such LOFAR, sensitivity is not a single value, but a multivariate function strongly dependent on elevation.

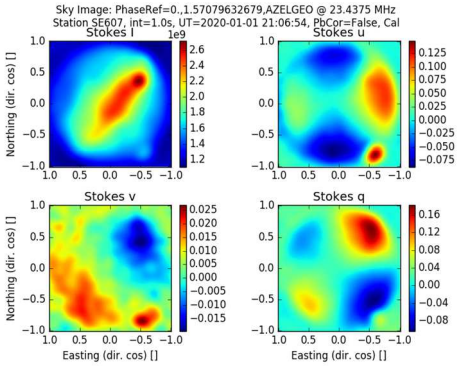

Figure 1. Polarimetric allsky image with a single LOFAR LBA station at 23.4 MHz. The Stokes I shows variation of sensitivity over the large field-of-view with sensitivity worsening towards the horizon. Stokes q, u, v show strong instrumental polarization due to the wide field-of-view and fixed-mount, digital pointing.

I will present recent results towards the calibration of such aperture arrays, and determining their sensitivity.

1. T. D. Carozzi, "New Definition for Dual-Polarized Antenna Sensitivity," *International Conference on Electromagnetics in Advanced Applications (ICEAA)*, 2019, pp. 0979-0981, doi:10.1109/ICEAA.2019.8878981.