Intrinsic Cross-polarization Ratio (IXR) for Antenna Arrays and Improving Polarimetry via Polarization Diversity

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Abstract: Future radio telescopes such as the SKA, will have to employ aperture arrays with full polarimetry for observations at the lowest frequencies. In the design and specification of such arrays it is therefore crucial to assess polarimetric performance, yet there is no standard method for doing this. Recently though, a fundamental quantity for the assessment of a single dual-polarized antenna was introduced in Carozzi & Woan, *IEEE T.A.P.* (2011) called the *intrinsic cross-polarization ratio* (IXR). IXR is essentially the Jones matrix condition expressed as a cross-polarization ratio, and as such it is a measure of how numerically stable the true polarization can be recovered from measured antenna voltages. Also, as it is simply related the Jones condition number, it is numerically easy to compute for a given Jones matrix. Thus IXR is ideal as a metric for the polarimetric fidelity of minimal, full-polarimetry antennas. Although the definition in Carozzi & Woan (2011) was for dual-polarized antennas, I will present a natural way of extending the IXR concept to an array with an arbitrary number of antenna elements, e.g. aperture arrays (AA), by using the matrix pseudo-inverse to express the matrix condition number. Using the IXR for arrays, I will also present how polarization diversity affects polarimetric performance. Polarization diversity here is the intentional variation in the alignment or relative rotation of elements or entire arrays. I will show that the IXR always improves when antennas are rotated relative each other, thus suggesting that polarimetric telescopes such as the SKA should consider rotating feeds and AA stations relative to each other as a simple and cheap way to boost the SKA's polarimetric performance. The physical rotation of the antennas can be coupled to an electronic back-rotation so that at the system level all antennas have the same apparent alignment in the end and thereby facilitating further processing of the polarization channels.