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A-to-Z Solver – Modeling the full Jones antenna aperture illumination pattern

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In this paper of a series describing direction dependent corrections for polarimetric radio imaging, we present the the A-to-Z solver methodology to model the full Jones antenna aperture illumination pattern (AIP) with Zernike polynomials. In order to achieve thermal noise limited imaging with modern radio interferometers, it is necessary to correct for the instrumental effects of the antenna primary beam (PB) as a function of time, frequency, and polarization. The wideband AW projection algorithm enables those corrections provided an accurate model of the AIP is available. We present the A-to-Z solver as a more versatile algorithm for the modeling of the AIP. It employs the orthonormal circular Zernike poly nomial basis to model the measured full Jones AIP. These full Jones models are then used to reconstruct the full Mueller AIP repsonse of an antenna, in principle accounting for all the off-axis leakage effects of the primary beam. The A-to-Z solver is general enough to accomodate any interferometer for which holographic measurements exist, we have success fully modelled the AIP of VLA, MeerKAT and ALMA as a demonstration of its versatility. We show that our models capture the PB morphology to high accuracy within the first 1-2 sidelobes, and show the viability of full Mueller gridding and deconvolution for any telescope given high quality holographic measurements.