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Radio Intereformetric Calibration using a Complex Student-t distribution and Wirtinger derivatives

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Calibration in radio astronomy is the step during which all systematic errors and ionospheric curruptions, are estimated and removed from the observed data. This consists of solving for all propagation effects, i.e. ̃Jones matrices, which minimizes the difference between the measured and the model data using a mathematical framework known as the Radio Interferometric Measurement Equation (RIME). The model data is constructed based on our existing knowledge of the observed field using a Gaussian likelihood function. However various outliers in the data and errors in the model cause deviations from the assumed likelihood function. This leads to "poor"' calibration solutions and formation of various artefacts in the calibrated images. These include generation of spurious sources, suppression in the flux of real structures and an increase in images' rms that reduces the detection probability of faint sources. Recently some authors (Kazemi and Yatawatta (2013); Ollier, Virginie, et al. ̃2016) have proposed using a different statistical noise model that better fits the noise as well, as unmodelled data and errors, in order to improve calibration. Kazemi and Yatawatta (2013) used a Student-t likelihood in place of a Gaussian likelihood and obtained considerable improvement in flux' suppression of the faint unmodelled sources. The algorithm implemented by Kazemi and Yatawatta (2013) requires us to separate the complex visibilities data in to real and imaginary parts, and independently solve for the real and imaginary parts of the gains. We derive and implement an analogue algorithm using a complex student-t distribution, which evicts the need of separating the data in their real and imaginary parts. This is achieve by exploiting the recent developments in optimization theory and particularly the Wirtinger calculus as explained by Smirnov and Tasse (2015) for gain calibration. We show results from simulations and the improvements obtained using the latter approach.

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