V111b Wavelets and sparsity for solving the inverse problem in Faraday tomography

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Faraday tomography is a technique that can provide tomographic information on magnetized astronomical objects, such as quasars, galaxies, or galaxy clusters. Faraday dispersion function (FDF), which contains this information, is calculated from the linear polarization data obtained through broadband polarimetry. However, the limited wavelength coverage of the instruments requires that we solve an ill-posed inverse problem when obtaining the FDF. We explore the use of wavelet transforms and the sparsity in the form of wavelet shrinkage (WS) for finding better solutions to the inverse problem. We recently proposed the Constraining and Restoring iterative Algorithm for Faraday Tomography (CRAFT; Cooray et al. 2021), a new flexible algorithm that showed significant improvements over the popular methods such as Rotation Measure Synthesis and RM CLEAN. In this work, we introduce CRAFT+WS, a new version of CRAFT incorporating the ideas of wavelets and sparsity. CRAFT+WS exhibit significant improvements even over the original CRAFT when tested for a complex FDF of realistic Galactic model. Reconstructions of FDFs demonstrate super-resolution in Faraday depth, uncovering previously unseen Faraday complexities in observations. The proposed approach will be necessary for effective cosmic magnetism studies using the Square Kilometre Array and its precursors.