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Imaging pipelines for polarimetric radio observations

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1 Extended Abstract

Traditionally, there has always been a distinction between polarimetric imaging and "regular" imaging of only Stokes *I*. The latter implied that the sky was assumed to be unpolarized. On modern radio interferometers like LOFAR, the JVLA, and in the future the SKA, the distinction is less clear. Antenna systems always convert at least some fraction of total intensity to polarization, and vice versa. Ignoring that fact will in fact deteriorate even Stokes I images, particularly when attempting to obtain high dynamic range, thermal noise limited images.

Proper treatment of polarization involves modeling and measuring the effect of all parts of the signal path from the source to the correlator output. In principle the process is simply a more elaborate version of the traditional self calibration loop:

1. pre-calibrate;
2. make images in *IQUV* and update sky model;
3. determine and apply signal path effects;
4. repeat from step 2.

Unfortunately, each step has its own challenges: making dirty *IQUV* images in every frequency band is easy, but deconvolving them properly is complicated: there may be extended, highly structured Galactic polarized emission everywhere in the field of view, violating the assumption that the sky is sparsely populated. Furthermore, the polarization will change dramatically as a function of frequency due to Faraday rotation as well as antenna properties, *and* the latter two effects may be time dependent.

Nearly all these problems must be dealt with in step 3. However, any errors accrued in step 2 will degrade the solutions found in step 3. Although over the past decade several tools and techniques have become available to deal with for example deconvolution of field-of-view-filling extended sources, source finding in RM-cubes, ionospheric calibration, and antenna beam modeling, tying them together is still a mostly manual process, requiring careful verification and sanity checks at every stage before proceeding.

I will provide an overview of the most important problems along the signal chain as well as the currently available techniques to deal with them.