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Instrumental Polarization across the Field of View of a Radio Telescope

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A radio telescope sees the sky through its beam. In aperture synthesis image processing it is commonplace to correct the total-intensity image for the primary beam, usually using a Gaussian function or some other simple mathematical form. The primary beam also has polarization properties that vary across the field of view. This paper presents computation of the instrumental polarization across the field of view of a paraboloidal reflector antenna, and investigates the contributions of reflector shape, feed cross-polarization, blockage by feed-support struts, and reflector roughness.

The computations use the GRASP 8 software, based on Physical Optics. The reflector is fed with a linearly polarized signal. Computed radiation patterns at four feed orientations from 0° to 135° in steps of 45° are averaged to provide a good approximation of the randomly polarized radio astronomy signal. Stokes parameters are calculated, and maps of Q/I and U/I are computed. These indicate the degree of conversion of I into Q and U by the telescope beam. The results of the computation are consistent with measurements made using unpolarized radio sources.

The computations show that the dominant source of instrumental polarization across the field is the cross-polarization of the feed. The next most significant effect is scattering by the feed struts. The differences between three-strut and four-strut configurations is quite obvious. Strut cross-section has a significant effect on polarization performance, and we show that struts of triangular cross-section give better polarization performance than circular struts. We present calculations of the Induced Field Ratio (the ratio of the size of the effective blockage caused by a strut to the blockage calculated from its physical size) for struts of various cross sections.

Surface roughness has relatively little effect in the main beam, but effectively randomizes the polarization of the sidelobes. This may be an advantage in an aperture synthesis telescope. Surface roughness introduces some spurious circular polarization because it introduces a small offset to the antenna geometry.

The computations show that the first and subsequent sidelobes are highly polarized, with levels of Q/I and U/I up to 50%.