RF OPTICS DESIGN FOR THE Q/U IMAGING EXPERIMENT

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Abstract Submission Form

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This paper describes the RF optics design of the Q/U Imaging ExperimenT (QUIET) intended to image the polarization of the cosmic microwave background (CMB) with detectors at two frequencies with unprecedented sensitivity. Observing the polarization of the CMB demands exquisite sensitivity to both Q and U Stokes parameters and freedom from systematic errors. QUIET makes use of recent breakthroughs in millimeter-wave circuit packaging to enable large arrays of radiometers or polarimeters for modest cost. Modules based on IC-style packaging with waveguide inputs provide fully functional pseudo correlation polarimeters capable of detecting Q and U simultaneously. The feeds themselves are corrugated horns built up from stacked platelets, each with an array of holes, defining one grove in each feed.

The optical design of the array is critical to the ultimate systematic performance as a polarimeter. Structures with asymmetric cross-polarization patterns create instrumental polarization (IP), the partial polarization of an otherwise unpolarized signal. Since the polarized E-mode CMB signal is at least a factor of 10 smaller than the unpolarized intensity fluctuations, minimizing IP is a prime concern for QUIET.

Only corrugated feed structures have demonstrated cross-polarization symmetry at the -35dB level over the required bandwidth of 80 to 105 GHz at W-band and 38 to 46 GHz at Q-band. For this reason, corrugated feed horns with the closest spacing allowable given the module size were chosen. The resulting outer feed diameter of 1.4 inches yields a beam size of 8 degrees at 90 GHz. Similarly, the 40 GHz feed with an outer diameter of 3 inches also yields a beam size of 8 degrees.

For the 1 and 2-meter class telescopes, a side fed Cassegrainian design was selected because of its excellent cross-polarization and wide angle scan performance. For either the one or two-meter design, an extremely large and flat field of view is realized with an angular extent of 12 on the sky. The 1-meter design can accommodate 91 feeds at W-band and 37 feeds at Q-band. At W-band the beam size is 0.31 degrees and at Q-band the beam size is 0.69 degrees. A two-meter design can accommodate 400 feeds at W-band and 91 feeds at Q-band. In fact, a three meter scale of the one-meter design would be capable of 1000 feeds at W-band.

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