Benchmark Parameters for CMB Polarization Experiments
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abstract The recently detected polarization of the cosmic microwave background (CMB) holds the potential for revealing the physics of inflation and gravitationally mapping the large-scale structure of the universe, if so called $B$-mode signals below $10^{-7}$, or tenths of a $\mu$K, can be reliably detected. We provide a language for describing systematic effects which distort the observed CMB temperature and polarization fields and so contaminate the $B$-modes. We identify 7 types of effects, described by 11 distortion fields, and show their association with known instrumental systematics such as common mode and differential gain fluctuations, line cross-coupling, pointing errors, and differential polarized beam effects. Because of aliasing from the small-scale structure in the CMB, even uncorrelated fluctuations in these effects can affect the large-scale $B$ modes relevant to gravitational waves. Many of these problems are greatly reduced by having an instrumental beam that resolves the primary anisotropies (FWHM $\ll 10'$). To reach the ultimate goal of an inflationary energy scale of $3 \times 10^{15}$ GeV, polarization distortion fluctuations must be controlled at the $10^{-2} - 10^{-3}$ level and temperature leakage to the $10^{-4} - 10^{-3}$ level depending on effect. For example pointing errors must be controlled to 1.5'' rms for arcminute scale beams or a percent of the Gaussian beam width for larger beams; low spatial frequency differential gain fluctuations or line cross-coupling must be eliminated at the level of $10^{-4}$ rms.