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Optical Characterization of BICEP3 and the Keck Array from 2016 to 2019

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The BICEP/Keck experiment (BK) is a series of small-aperture refracting telescopes observing degree-scale Cosmic Microwave Background (CMB) polarization from the South Pole in search of a primordial B-mode signature. This B-mode signal arises from inflationary gravitational waves interacting with the CMB, and has amplitude parametrized by the tensor-to-scalar ratio r. Since 2016, BICEP3 and the Keck Array have been observing with 2400 antenna-coupled transition-edge sensor detectors each, with frequency bands spanning 95, 150, 220, and 270 GHz. Here we present the optical performance of these receivers from 2016 to 2019, including far field beams measured in situ with an improved chopped thermal source and instrument spectral response measured with a field-deployable Fourier Transform Spectrometer. As a pair differencing experiment, an important systematic that must be controlled is the differential beam response between the co-located, orthogonally polarized detectors. We show per-detector far field beam maps and the corresponding differential beam mismatch that is used to estimate the temperature-to-polarization leakage in our CMB maps and to give feedback on detector and optics fabrication. The differential beam parameters presented here were estimated using improved low-level beam map analysis techniques, including efficient removal of non-Gaussian noise as well as improved spatial masking. These techniques help minimize systematic uncertainty in the beam analysis, with the goal of constraining the bias on r induced by temperature-to-polarization leakage to be subdominant to the statistical uncertainty. This is essential as we progress to higher detector counts in the next generation of CMB experiments.

Less than 5 years of experience since completion of Ph.D

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