The BICEP/Keck CMB Polarization Approach: Measuring Degree Angular Scales with Small Apertures

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The BICEP/Keck Array cosmic microwave background (CMB) polarization experiments located at the South Pole are a series of small-aperture refracting telescopes focused on the degree-scale B-mode signature of inflationary gravitational waves. These highly-targeted experiments have produced the world's deepest maps of CMB polarization, leading to the most stringent constraints on the tensor-to-scalar ratio to date: $\sigma(r) = 0.024$ and $r < 0.09$ from B-modes alone, and $r < 0.07$ in combination with other datasets. These constraints will rapidly improve with upcoming measurements at the multiple frequencies needed to separate Galactic foregrounds from the CMB, and in combination with higher-resolution experiments to remove B-modes induced by gravitational lensing.

I will review several aspects of the BICEP/Keck instrument design which are key to maximizing polarization sensitivity and reducing systematics at large angular scales: common-mode noise rejection through differencing of orthogonally polarized detector pairs, reduction of far sidelobes with co-moving absorptive forebaffles, and consistency checks/cancellation of systematics using boresight rotation. I will discuss the extensive far field beam measurements taken in situ at the South Pole every year, and how the resulting high-fidelity beam maps for each detector are used to predict the expected temperature-to-polarization leakage – the leading instrumental systematic for pair differencing experiments – in the final CMB maps. Finally, I will discuss the prospects for dealing with temperature-to-polarization leakage in next-generation CMB experiments with hundreds of thousands of detectors, and how the beams systematics levels we achieve with current instrument and analysis technology will scale with detector count.