Overview of Detector Arrays for the Measurement of Cosmic Microwave Background Polarization

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The Cosmic Microwave Background (CMB) is powerful probe of cosmology. It has played a central role in the development of a 'standard cosmological model', in which the universe expanded from a singularity, initial perturbations are adiabatic with a near scale-invariant spectrum, and the universe is filled with mostly dark energy and dark matter. Future measurements of CMB polarization may be used to constrain an inflationary epoch in the early universe, probe the growth rate of structure, understand the nature of neutrinos and perhaps provide an experimental probe of quantum gravity. Excitement over these prospects has spurred plans for next-generation CMB instruments, both from space and from the ground. LiteBIRD and CORE are JAXA and ESA-proposed space-based missions under study, respectively. The future of ground-based CMB observing is 'CMB Stage IV,' a community-wide effort to map roughly half the sky to 1 μK-arcmin depths in the decade to come.

These developments and demands have fueled much innovation in detector technology. Since CMB observations require extremely low signal to noise measurements, contemporary CMB focal planes contain arrays of thousands of sensing elements in order to increase mapping speed. Yet these focal planes are quite diverse, with several groups developing separate approaches to measure CMB polarization. One class of detector focal planes utilizes arrays of fully integrated superconducting circuits. Pixels contain dual-polarization sensitive antennas, passband defining filters, and cryogenic bolometers as sensing elements. One variant on this theme even partitions the signal from a broad-band antenna into multiple spectral bands for foreground discrimination. A separate class of detectors consists of filled arrays of direct absorbers that are polarization insensitive. In this case, polarization sensitivity is achieved by use of a wire-grid analyzer placed in front of the array.

In this talk, I will overview the state-of-the-art in the development, production, and use of CMB detectors. I focus exclusively on direct detectors, and will compare and contrast transition edge sensor (TES) based arrays, which have been the workhorse sensor for the CMB, with arrays of microwave kinetic inductance detectors (MKIDs). The latter technology has not yet been used in a CMB instrument but holds promise due to pixel-count scalability. Lastly, I will discuss the prospects for meeting the stringent detector demands of CMB-Stage IV.