LEKID-based instruments for cosmic microwave background polarimetry

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After years of research and development, lumped-element kinetic inductance detectors (LEKIDs) are now competitive with other detector technologies for studying the polarization of the cosmic microwave background (CMB) radiation. One ultimate goal of this effort is the detection of the so-called inflationary B-mode polarization signature, which would yield the most convincing evidence for the theories of inflation and, if detected, would constrain the energy scale of these theories. The B-mode signal is predicted to be extremely small—in the nanokelvin range—requiring excellent sensitivity and exquisite control of systematics.

At Columbia we are leading an effort to develop a new generation of CMB polarimeters based around LEKIDs. These detectors are straightforward to fabricate using only 2–3 photolithography masks and are inherently multiplexible. Research on LEKIDs has advanced to the point where we can now reliably design and fabricate detectors with photon-limited noise performance over a wide range of optical loading conditions, making them extremely competitive with traditional TES bolometers.

These new instruments employ a novel optics design enabled by advances in metal-mesh half-wave plate (HWP) technology made by the Ade lab at Cardiff, which are now available in 50 cm diameters. This large diameter makes it possible to place the HWP modulator near the very beginning of the optical path. The HWP will be rotated using a superconducting-magnetic bearing and contactless motor to eliminate heating and vibration issues which have plagued other experiments. We are taking advantage of the sub-millisecond time constants which LEKIDs provide by rapidly rotating the HWP and rapidly scanning the telescope to achieve excellent sensitivity over a wide range of angular scales by avoiding $1/f$ noise from atmospheric and other sources. The combination of the optical design, the fast time constants of the LEKIDs, and a rapid scan strategy will provide unprecedented control of systematics.

This talk will give an overview of our efforts in designing and deploying both ground-based and balloon-based instruments using these technologies.