LEKID (and CASPER) Development at Columbia

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Collaborators

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Motivation: Detecting confirming evidence for inflation in the CMB polarization

$\sqrt{\ell (\ell + 1) C_\ell / 2\pi}$ [\(\mu K\)]

- $\Omega_\Lambda = 0.693$
- $\Omega_{\text{cdm}} = 0.257$
- $\Omega_b = 0.0481$
- $\tau = 0.089$
- $\tau = 0.1$ & $0.01$

WMAP 9-year anisotropy map
Challenges and strategies

- **Sensitivity**
  - Need thousands of photon-noise limited detectors
  - Low loading
    - Atmospheric – high sites and balloons
    - Instrumental – cold optics

- **Systematics**
  - Clean, cold optics design
  - Rapid scanning
  - Rotating cold half-wave plate (HWP) modulator early in optical path
  - Multiple frequency bands (150, 210, 267, 350 GHz)
  - Cross-linking

LEKIDs help here!
Re-flyable balloon-based instrument concept

SKIP: Stratospheric Kinetic Inductance Polarimeter

- Thin window
- Cold snout
- Rapidly rotating metal-mesh HWP
- Superconducting magnetic bearing

- 1 K cold optics
- 2313 element horn-coupled LEKID array
- Robust, re-flyable gondola design
- LN2/LHe cryostat
General (M)KID Schematic

Microwave Kinetic Inductance Detectors
Example LEKIDs

Lumped Element Kinetic Inductance Detectors
Example LEKIDs
LEKID Response to Optical Power

![Graph showing the response of LEKID to optical power with varying temperatures and frequency offset.](image)
Basic Homodyne KID Readout
FPGA KID Readout Basic Diagram

1. ADC
2. PFB & FFT
3. Channel Select
4. DRAM Waveform Circular Buffer
5. DAC
6. LPF
7. NCO
8. Further Processing
CUKIDS: Open-source KID readout firmware/software developed at Columbia

• Focus so far is on lab testing
  – Should be suitable for full instruments
• Very simple design; most processing is done offline
• Based on ROACH + MUSIC ADC/DAC
  – Readout via PPC 100 MbE (bottleneck)
    • 4 x 250 kHz or 32 x 7.5 kHz
  – Can be easily adapted to use 10 GbE
• [https://github.com/ColumbiaCMB/kid_readout](https://github.com/ColumbiaCMB/kid_readout)
• Currently includes KID data analysis code too
• Python libraries (and example GUI)
LEKID Optical Testing
Example quick-look plot