Design and readout of large MKID arrays for submillimeter astronomy

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Abstract

Microwave Kinetic Inductance Detectors (MKIDs) are superconducting microresonators useful as detectors for sub/millimeter and far-infrared cameras, as well as instruments in optical and x-ray wavelengths. A probe sine wave at the resonance frequency can detect a change in frequency and microwave loss due to submillimeter optical load as a phase or amplitude change. These detectors may be coupled to light through on-chip, phased-array antennas. A single antenna may feed several detectors with different bandpasses defined by on-chip lumped-element filters. The resonators are easily frequency multiplexed by tuning the resonance frequencies, so hundreds of detectors can be read out while coupled to a single feedline.

The deployment and operation of ground-based, background-limited detectors in close-packed arrays present significant challenges in both readout strategy and array design. The initial designs consisted of simple coplanar waveguide microwave resonators with aluminum absorptive sections. The first change has been to substitute the capacitive portion of the resonator with a large interdigitated capacitor (IDC) to reduce its noise contribution. While their low-noise characteristics have been demonstrated, these detectors had not yet been tested on array-scale devices. We present results from arrays of detectors designed for sub/millimeter imaging, tested for their optical response characteristics. In particular, we address challenges of microwave inter-resonator coupling, out-of-band resonator optical sensitivity, and noise reduction in the latest device designs. We show the results of stepped-impedance filters in preventing direct pickup of wide-band radiation, and new frequency spacing to limit crosstalk between resonators. We show direct comparison between older-design coplanar waveguide resonators and new IDC resonators under optical load, demonstrating the noise reduction and comparable responsivity. In addition, we show results of the probe signal readout power that maximizes signal-to-noise.