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Development of low-noise multiband imaging arrays using microwave kinetic inductance detectors (MKID) for ground-based submillimeter astronomy

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***Abstract*—The population of submillimeter-bright galaxies (SMGs) at high redshifts, first studied with the JCMT/SCUBA instrument in 1997, is potentially a very rich source of information for advancing our understanding of the formation and evolution of galaxies over cosmic history, and especially elucidating the role of galaxy merger events. While single-band imaging surveys have now revealed hundreds of SMGs, further progress will require multi-band information in order to measure spectral indices and luminosities and for selecting objects for targeted follow-up observations, e.g. with ALMA. The first steps in this direction are already being taken: the 10m South Pole Telescope is finding galaxies at 150 GHz and 220 GHz using TES bolometer array cameras, and the BLAST balloon instrument has made galaxy surveys at 250, 350, and 500 microns. Ultimately, surveys with bigger telescopes (such as the proposed 25m CCAT) equipped with large multiband imagers will be needed.**

As a step toward this ultimate goal, we are constructing MKIDCam, a 576 spatial pixel 4-band (750, 850, 1100, 1300 microns) camera to be deployed at the Caltech Submillimeter Observatory (CSO) in 2010. The focal plane arrays, optics, readout electronics, and cryogenics are currently under development. The focal plane will consist of 24 x 24 spatial pixels responding simultaneously to all four bands and assembled as a mosaic of 16 tiles. Each 6 x 6 pixel tile will have 144 frequency-multiplexed Microwave Kinetic Inductance Detectors (MKIDs). Individual pixels consist of a phased-array planar antenna, on-chip filters for band separation, and four MKIDs for simultaneous measurement of the four bands. The MKID readout will be performed using cryogenic HEMT amplifiers followed by room-temperature FPGA-based channelization electronics.

At present, tests on prototype 4x4 two-band arrays are being performed and critical properties such as responsivity, noise, quasiparticle lifetime, optical efficiency, optical bandpass response, and magnetic field sensitivity are being measured. The MKID resonators show excess frequency noise due to perturbations in the dielectric constant of a surface layer containing two-level system (TLS) fluctuators. Based on a semi-empirical TLS noise model, we have designed and fabricated new resonators using modified geometries such as interdigitated capacitors. Measurements of these devices have confirmed a reduction in frequency noise by roughly an order of magnitude compared to our previous conventional CPW resonators. These results suggest that the optically-loaded frequency-readout NEP for these devices could be appropriate for reaching the photon background limit at the CSO ($5 – 15\times10^{-17}$ W Hz$^{-1/2}$). A second engineering run with a 6x6 pixel 3-band array prototype camera incorporating the new lower noise resonator designs is planned at the CSO in 2009.