YBCO Kinetic Inductance Bolometers for Hyperspectral Imaging of Cold Planetary Objects

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To gain understanding about the origins and evolution of the solar system, and possible habitable climates therein, the 2013 Planetary Science Decadal Survey recommends a number of missions that require thermal imaging and compositional analysis of cold bodies. The Trojan Tour and Rendezvous mission requires characterization of the surfaces of multiple Trojan asteroids. The Comet Surface Sample return requires characterization of the surface area from which the sample is retrieved. And, the Jupiter Europa Orbiter requires thermal imaging and compositional surveys of Europa's ice for organic and inorganic compounds.

We are developing superconducting bolometer arrays for the focal planes of thermal imagers to offer detailed characterization of such cold bodies. Working in combination with a wavelength dispersive element such as an Offner grating or a FTIR spectrometer, these arrays will provide thermal images with hyperspectral wavelength resolution of each spatial pixel. Instruments based on this technology could produce maps of the surface composition of bodies, much like the lunar diviner or the moon mineralogy mapper, except that the hyperspectral thermal imager would measure longer wavelengths (5 microns to 100 microns) and will be sensitive enough to measure high resolution thermal spectra from the icy moons of Jupiter and the cold primitive bodies of the outer solar system. The hyperspectral thermal imager may serve as significant advancement over standard thermal imagers and would complement information gathered from other spectrometers that function at smaller wavelengths.

The bolometers are fabricated out of the high temperature superconductor YBCO, which is patterned to form kinetic inductance devices (KIDs). Each KID is suspended on a thin membrane to thermally isolate it so that it functions as bolometer. The KIDs are easily multiplexed so that arrays of thousands of bolometers, each 0.5 mm in size, are practical. These devices operate at 50 K to offer much higher sensitivity compared to standard radiometers at 300 K. Because they operate at 50K, they do not require complex coolers that are required for bolometers made of low temperature superconductors. The use of passive cooling or existing low-mass low-power coolers makes these bolometers practical for instruments on planetary science missions.