

Ultra-Compact Superconducting Spectrometer on a Chip at Submillimeter Wavelengths

G. Chattopadhyay[1*], P. Barry, C. M. Bradford, P. Day, S. Doyle, S. Hailey-Dunshath, A. Kovacs, H. G. Leduc, N. Llombart, C. McKenny, , D. P. Marrone, P. Mauskopf, R. O'Brient, S. Padin, E. Shirokoff, J. Siles, L. Swenson, and J. Zmuidzinas

[1]*NASA-Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA.*

* Contact: goutam@jpl.nasa.gov, phone +1-818-216-1091

***Abstract*— In this paper we will describe a novel, moderate-resolving-power (R~700), ultra-compact spectrograph-on-a-chip for millimeter and submillimeter wavelength which is currently under development. It's very small size, wide spectral bandwidth, and highly multiplexed detector readout will enable construction of powerful multi-beam spectrometers for high-redshift observations. The octave-bandwidth background-limited performance of this spectrometer is comparable to that of a diffraction grating, but in a photo-lithographically developed thin-film package with size ~10 λ x 10 λ. In general, even the most compact grating spectrometers are 2-D structures with size ~ $\lambda R/\sqrt{\varepsilon}$. The grating sizes for these spectrometers are prohibitive, approximately 1 meter for R=1000 at λ=1 mm in free space, and ~30 cm in silicon. This fundamental size issue is a key limitation for space based spectrometers for astrophysics applications. On the other hand, our photo-lithographic on-chip spectrometer camera is compact delivering 200 – 500 km/s spectral resolution over and octave bandwidth for every pixel in a telescope's field-of-view.**

The spectrometer employs a filter bank consisting of planar, lithographed superconducting transmission line resonators. Each mm-wave resonator is weakly coupled to both the feedline and to the inductive portion of a lumped element Microwave Kinetic Inductance Detector (MKID). Incoming mm-wave radiation breaks Cooper pairs in the MKID, modifying its kinetic inductance and resonant frequency, allowing for frequency-multiplexed readout. The design is realized using thin film lithographic structures on a Si wafer, with titanium nitride MKID resonators. In this paper, we will discuss the design and optimization of the MKID detectors for the spectrometer and the measured performance of a laboratory test device. We will also describe the ongoing development of a demonstration instrument which will consist of two 500-channel, R=700 spectrometers, one operating in the 1-mm atmospheric window and the other covering the 650 and 850 micron bands.

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