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Device-Level Noise Physics of SuperSpec's Extremely Low Volume Titanium Nitride Kinetic Inductance Detectors

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SuperSpec is a new technology for millimeter and submillimeter spectroscopy. It is an on-chip spectrometer being developed for multi-object, moderate resolution, large bandwidth survey spectroscopy of high-redshift galaxies for the 1 mm atmospheric window. SuperSpec targets the CO ladder in the redshift range of z = 0 to 4, the [CII] 158 um line from z = 5 to 9, and the [NII] 205 um line from z = 4 to 7. All together these lines offer complete redshift coverage from z = 0 to 9. SuperSpec employs a novel architecture in which detectors are coupled to a series of resonant filters along a single microwave feedline instead of using dispersive optics. This construction allows for the creation of a full spectrometer occupying as few as several cms squared of silicon, a reduction in size of several orders of magnitude when compared to standard grating spectrometers. This small profile enables the production of future multi-object spectroscopic instruments required as the millimeter-wave spectroscopy field matures.

The SuperSpec filterbank is coupled to the inductive meander of titanium nitride (TiN) kinetic inductance detectors (KIDs), which serve as the power detectors. The unique coupling scheme employed by SuperSpec allows for the creation of extremely low volume (~2.5 cubic microns), high responsivity, TiN KIDs. Since responsivity is proportional to the inverse of quasiparticle-occupied volume, this allows SuperSpec to reach very low NEPs.

We investigate in detail the noise properties of these extreme detectors. In particular, we examine the scaling of both white noise and 1/f noise with respect to array temperature, loading, volume, and superconducting transition temperature (Tc). We will compare these measurements to analytical models for the expected noise levels. Finally, we will additionally present measured time constants for the SuperSpec detectors.

Student (Ph.D., M.Sc. or B.Sc.)

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Less than 5 years of experience since completion of Ph.D

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Primary authors: WHEELER, Jordan (University of Colorado - Boulder); HAILEY-DUNSHEATH, Steven (California Institute of Technology); REDFORD, Joseph (California Institute of Technology); KARKARE, Kirit (University of Chicago); Dr BRADFORD, Matt (JPL); GLENN, Jason (University of Colorado - Boulder); SHIROKOFF, Erik (University of Chicago); BARRY, Pete (Cardiff University); LEDUC, Henry G. (Jet Propulsion Laboratory); MAUSKOPF, Phillip (Arizona State University); MCGEEHAN, Ryan (University of Chicago); ZMUIDZINAS, Jonas (California Institute of Technology); JANSSEN, Reinier (Jet Propulsion Laboratory); GORDON, Samuel (School of Earth and Space Exploration, Arizona State University)

Presenter: WHEELER, Jordan (University of Colorado - Boulder)

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