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Keithley Award Talk

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Superconducting transition-edge sensors (TES) operated at temperatures below 1 K are a sensitive tool for the detection of electromagnetic radiation from microwaves through gamma rays, and for the measurement of the energy of particle interactions and nuclear decays. They have evolved beyond the research and development phase, and they are being used in applications as diverse as astronomy, nuclear and particle physics, and materials science. The low noise, low source impedance, and low operating temperature of superconducting quantum interference devices (SQUIDs) make them the preamplifier of choice for TES devices. In order to realize their full potential, it has been necessary to develop arrays of thousands of SQUID-coupled transition-edge sensors. Due to constraints on cryogenic wiring and circuit complexity, SQUID multiplexing is necessary to realize these advances. In this talk, I will describe the development of large arrays of TES detectors integrated with multiplexed SQUID amplifiers. SQUID multiplexers use an orthogonal basis set (usually time- or frequency-division) to encode the signal from many input channels into a single wire. I will discuss both fundamental limits and practical issues of implementation, including bandwidth-limiting filters, power dissipation, and crosstalk. I will highlight work done by our group at the National Institute of Standards and Technology to develop time-division multiplexed arrays of thousands of SQUID amplifiers, and collaborations with different groups to integrate them into large arrays of TES sensors for a variety of applications. I will also discuss future trends, including the development of microwave techniques to read out even larger arrays of SQUID amplifiers in high-Q resonant circuits.