Modeling Reversible and Irreversible Behavior in Superconducting Transition-Edge Sensors

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Superconducting transition-edge sensors (TESs) are under development for applications across the electromagnetic spectrum from gamma-ray to microwave radiation. Common to all applications is precisely measuring thermal energy using a superconductor's resistive phase transition. Control of the resistive transition and its dependences on temperature, current, and magnetic field is paramount to a TES's design and optimization. We present a model of the TES transition over a large design space with different superconducting, normal metal, and current injection geometries, different bias circuits, along with dependences upon stray and applied magnetic fields.

In addition to the coarse transition shape it is common to find, even in the highest energy resolving power detectors, fine features in the resistive transition consisting of small discontinuities and other nonlinear structure. The very best energy resolution is often achieved by carefully operating the detectors in regions of the transition free of these features. We investigate the nature of this structure and how it relates to measurements of the TES's current distribution under standard bias conditions.