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Exploring the superconducting transition in transition-edge sensors and the consequences for both ac and dc bias

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Recent research into the superconducting transition of transition-edge sensors (TESs) has highlighted the importance of a variety of physical phenomena, including the lateral and longitudinal proximity effects and phase-slips. These effects are important to understanding the steepness and linearity of the transition and its sensitivity to temperature, current and magnetic field. Beyond the global shape of the R(I,T,B) surface, there can be regions of the transition that have dramatically increased noise and exhibit switching between distinct current states. Often these locally noisy regions limit the useful operating regions of the TES to small sub-regions of the overall transition. Understanding the cause of the noisy regions and how to avoid these regions is important for achieving the best spectral resolution for both dc and ac bias.

In this work, we explore both the global and local behavior of the transition across a variety of device sizes and normal metal structures. In particular, we present results that show a clear evolution from weak-link to phase-slip behavior as device size increases. We use several well-understood characterization techniques including critical current measurements, current-voltage characteristics, and impedance measurements. We also show results obtained from more unusual techniques including devices with multiple internal voltage taps and optical characterization. We compare our results to both weak-link and phase-slip interpretations of the superconducting transition.

I_c vs. T for different size TESs

Demonstrates transition from Ginzburg-Landau thin-film behavior to weak-link behavior