Possible Transition-Edge Operation of Diffusion-Cooled Hot-Electron Bolometers

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Like other bolometers, superconducting hot-electron bolometers (HEB's) generate thermal fluctuation (TF) noise. The origin is the fundamental thermodynamic fluctuations in energy of a small system that is in thermal contact with a large reservoir. These energy fluctuations cause resistance fluctuations in the HEB that can be detected as voltage fluctuations (or output noise) when a DC current is run through the device.

When comparing the amount of TF noise that is generated by diffusion-cooled HEB's to theory, one finds a reasonable agreement for small DC currents, up to a few microamps, with the output noise power showing the expected proportionality to the square of the DC current. This is not seen experimentally for higher currents, and for diffusion-cooled HEB's operated as mixers the amount of TF noise generated is usually at least an order of magnitude less than the predictions. The diffusion cooling mechanism creates a roughly parabolic temperature distribution inside the device, with a temperature larger than Tc at the center of the device, and with the temperature at the ends pinned by the (ambient) temperature of the contacts. A result is that only a small fraction of the device is actually close enough to Tc to generate TF noise (or to mix), creating a situation of low TF noise and low mixer conversion.

Our measurements indicate that it is possible to achieve a better agreement between the parabolic temperature distribution and Tc by taking advantage of the suppression of Tc that is seen in the end regions of diffusion-cooled HEB's. In the talk we will present data from measurements with tantalum HEB's, showing that the amount of TF noise generated can be increased significantly if parameters such as device length and operating temperature are selected appropriately.

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