DETECTION AND INTERPRETATION OF BISTABILITY EFFECTS IN NbN HEB DEVICES

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All Hot Electron Bolometer (HEB) devices exhibit instability when biased in the bias voltage range between the point where the HEB device strip stops being superconducting and where a stable hotspot is formed. Although such effects disappear when a sufficient amount of LO power is applied, the stable and unstable regions are not always well separated. Also, we believe that interpretation of the phenomena which give rise to the instabilities may help us develop better models for the device under optimum (lowest receiver noise temperature) conditions. For example, recent modeling using the active zone model (with LO power applied) showed that a bistable solution was obtained at low bias voltages [1]. We have studied NbN HEB devices under conditions such that the intrinsic behavior of the devices (rather than external circuit effects) dominated. The devices used in the experiments are NbN devices with thickness of the NbN film of 3.5~5 nm, and strip dimensions of 5 μm width and 1 μm length. The devices were mounted on a circuit board in a metal box to eliminate outside perturbations and minimize circuit parasitics. This study extends one reported at the previous STT symposium [2]. Oscillation waveforms of both the voltage and current of the device were observed simultaneously on a digital oscilloscope. When the current through the device is increased beyond the critical current, high voltage spikes with a repetition frequency of about 6 MHz appear across the device and the current drops to a lower value. The amplitude of the voltage spikes is equal to the normal resistance of the device times the low value of the current, which means that the entire device is normal at the peak of a voltage spike. When the device is then rapidly cooled, it becomes superconducting with zero voltage across it, since there is not enough power to maintain the normal state. During the spiking, the device thus exhibits a *bistable* behavior, as described in for instance ref. [3]. In this paper we will interpret the measured data described above, as well as other measured data, in terms of this general bistability model. Specifically, we will also show that effects due to vortices can not be responsible for the voltage spikes, since all typical HEB devices in use to-day are too small to be able to accommodate even a single vortex.

[1] H.F. Merkel, P. Khosropanah, K.S. Yngvesson, S. Cherednichenko, M. Kroug, A. Adam, and E.L. Kollberg, "An Active Zone Small Signal Model for Hot Electron Bolometric Mixers," 12th Intern. Symp. Space THz Technol, San Diego, CA, Febr. 2001, pp. 67-74.
[2] Y. Zhuang and K.S. Yngvesson, "Negative Resistance Effects in NbN HEB Devices," ibid, pp. 143-153.
[3] A.VI. Gurevich and R.G. Mints, "Self-Heating in Normal Metals and Superconductors," *Rev. Mod. Physics*, **59**, 941 (1987).