Quantum Mechanical Mixing Model for Hot Electron Bolometers

Harald F. Merkel, P. Khosropanah, T. Berg, S. Cherednichenko, E. Kollberg
Chalmers University of Technology
412 96 Göteborg, Sweden

In recent experiments, quantum effects have become visible in the device noise of hot electron bolometers. Modelling attempts have been made to asses this additional noise [1] Here a model is presented, where the bolometer is associated with a photon counting operator. Since the local oscillator and the radio frequency signal are treated as photon flows, a stochastic fluctuation of the absorbed power in time is caused by the graininess of the incoming radiation. Applying counting operators to the downconverted signal and using a simple Poisson distribution for the presence or absence of a photon, a closed form expression for the quantum noise of the HEB is found that is similar to the relations given in [1]. Quantum noise is a substantial part in the mixer noise at larger THz frequencies and dominates the mixer noise of NbN phonon cooled HEB at frequencies around 8THz and above. Quantum noise contributions are found to be subject to the same electrothermal feedback process as fluctuation and thermal noise are. A way to minimize quantum noise contribution is one is achieved by a correct matching of the active part of the bolometer to the antenna. On the other side, for frequencies above the quasiparticle bandgap, the whole HEB must be matched to the antenna for optimum performance so the best mixer performance lies in between these extrema.

[1] S. Yngvesson, E. Kollberg, Proceedings 14th. ISSTT , 2003 Tucson, AZ