A Resonance Cold-Electron Bolometer with a Kinetic Inductance Nanofilter

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A novel type of resonance cold-electron bolometer (RCEB) is proposed. In this sensor, the internal resonance is organized by the kinetic inductance of an ultrasmall NbN superconducting nanostrip and the capacitance of the nanoscale SIN (Superconductor-Insulator Normal) tunnel junction. Decisive breakthrough was done by implementation of the CEB with kinetic inductance of superconducting absorber and normal metal traps [1, 2] with proper resonance properties. The kinetic inductance is about 300 times smaller than the geometrical inductance of the same value. This reduction of size gives an opportunity to create nanofilters with a total size considerably smaller than the wavelength. This internal resonance acts as a bandpass filter (instead of external filters) with a bandwidth of 3-50%, something needed for radioastronomy applications [3].

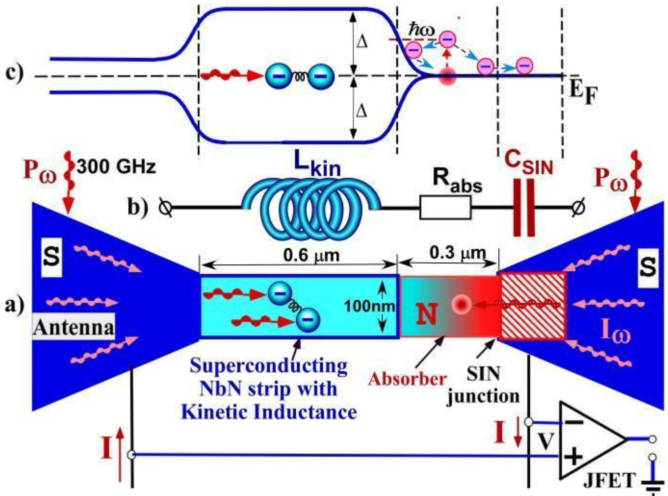

Fig 1. a) Sketch of the Resonance Cold-Electron Bolometer (RCEB) with kinetic inductance of the superconducting NbN strip and capacitance of the SIN tunnel junction as an RF internal filter. b) Equivalent scheme of the bolometer including kinetic inductance L_{kin}, the capacitance of the tunnel junction C_{sin}, and resistance of absorber Rabs with typical parameters for 300 GHz; c) Energy diagram of RCEB with $\Delta > hf$.

The NbN protection against escaping hot quasiparticles provides a unique opportunity to create an optimal CEB with only one SIN junction and an Andreev SN contact for thermal protection, in contrast to a classical CEB with two SIN junctions. The well-known problem of hot quasiparticles escaping over the Andreev barrier (Δ) is overcome here by creating a barrier higher than quantum energy Δ>hf to have working kinetic inductance. Replacing two SIN junctions by one junction, we could use this junction of half the area to keep the same capacitive coupling. Therefore, a single-junction RCEB would have four times less area of junctions (and volume of absorber) in comparison with a two-junction RCEB and should show better noise performance due to the proportionally decreased e-ph noise component.

The RCEB can be effectively used to create multiband elements that are actual tasks in radioastronomy due to the benefit that comes from its ability to use co-located data, and problems with the dramatic increase of the size of the focal plane.

References

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2. L. S. Kuzmin, "Superconducting Cold-Electron Bolometer with Proximity Traps", Microelectronic Engineering, 69, 309-316 (2003).

3. L. S. Kuzmin, "Resonance Cold-Electron Bolometers with a Kinetic Inductance Nanofilter, submitted to IEEE TST, Sept. 2013