Anomalous photonic heat transport across a Josephson junction in a highly dissipative environment

Olivier Maillet[1,2], Diego Subero[2], Dmitry Golubev[2], and Jukka Pekola[2]

[1]*CEA Saclay, Bât. 772, Orme des Merisiers CEA Saclay, F-91191 Gif sur Yvette Cedex, France*

[2]*Department of Applied Physics, School of Science, Aalto University*

A small Josephson junction in a high-impedance Ohmic environment is a good example of a quantum-mechanical degree of freedom (the junction's phase difference) strongly coupled to its thermal reservoir (e.g. resistors emitting/absorbing photons). DC charge transport in such a system has long been understood in the framework of dynamical Coulomb Blockade [1], where the back-action of the environment inhibits the tunneling of charges across the junction. Intuitively, one could foresee that heat transport of photons between two high resistances put on each side of the junction should be suppressed as well, since this transport translates as supercurrent fluctuations flowing across the junction linking the two resistors.

Here, we report on an experiment showing that, on the contrary, heat transport survives in the high-impedance limit where charge transport vanishes, with a strength that remain close to the limit imposed by the quantum of thermal conductance. This survival cannot be accounted for by the standard theory of dynamical Coulomb Blockade. In light of recent theoretical [2] and experimental [3] developments, we conjecture that, because of the junction's phase slips, inelastic scattering of thermal photons emitted by one resistor results in heavily down-converted, low-energy photons that are nonetheless transmitted to the other resistor, preserving the heat flow, which is a broadband signal.

[1] G.-L. Ingold and Yu. V. Nazarov, "Charge Tunneling Rates in Ultrasmall Junctions", in "Single Charge Tunneling", edited by H. Grabert and M. H. Devoret, NATO ASI Series B, Vol. 294, pp. 21-107 (Plenum Press, New York, 1992)

[2] Moshe Goldstein, Michel H. Devoret, Manuel Houzet, and Leonid I. Glazman, "Inelastic Microwave Photon Scattering off a Quantum Impurity in a Josephson-Junction Array" Phys. Rev. Lett. 110, 017002 (2013)

[3] R. V. Kuzmin, N. Grabon, N. Mehta, A. Burshtein, M. Goldstein, M. Houzet, L. I. Glazman, V. E. Manucharyan, "Inelastic scattering of a photon on a quantum phase slip" Physical Review Letters 126, 197701 (2021)