QUANTUM-LIMITED HEAT CONDUCTION OVER MACROSCOPIC DISTANCES

M. Partanen, K. Y. Tan, J. Govenius, R. E. Lake, M. K. Mäkelä, T. Tanttu, and M. Möttönen

QCD Labs, COMP Centre of Excellence, Department of Applied Physics, Aalto University, P.O. Box 13500, FIN-00076 Aalto, Finland
email: matti.t.partanen@aalto.fi

Quantum mechanics sets a fundamental upper limit for single-channel heat conduction, known as the quantum of thermal conductance [1]. It has previously been observed over distances below 100 μm [2, 3], which is, however, insufficient for many applications. Here, we experimentally study the quantum of thermal conductance over distances up to a meter. The studied system consists of two normal-metal islands connected by a superconducting transmission line, as shown in Fig. 1. The temperature control and thermometry are realized by normal-metal–insulator–superconductor junctions. We observe the essentially quantum-limited photonic heat conduction to be the dominating heat conduction mechanism between the normal-metal islands. The methods studied here can potentially be applied in the emerging field of quantum nanoelectronics as they provide a solution for remote temperature control of critical components. Especially, these methods are compatible with circuit quantum electrodynamics, which is a potential basis for a superconducting quantum computer [4].

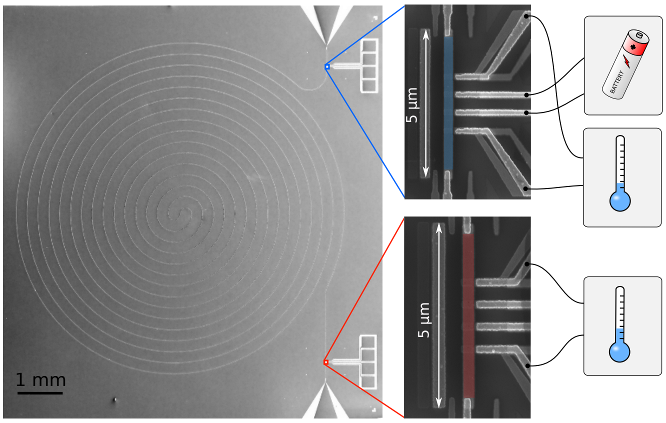

Figure 1: Sample structure and the measurement scheme. The temperatures of both normal-metal islands are measured while the temperature of the upper island is controlled with an external voltage.

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