Thermally driven quantum refrigerator autonomously resets superconducting qubit

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Abstract

The first thermal machines steered the industrial revolution, but their quantum analogs have yet to prove useful. Here, we demonstrate a useful quantum absorption refrigerator formed from superconducting circuits. We use it to reset a transmon qubit to a temperature lower than that achievable with any one available bath. The process is driven by a thermal gradient and is autonomous -- requires no external control. The refrigerator exploits an engineered three-body interaction between the target qubit and two auxiliary qudits coupled to thermal environments. The environments consist of microwave waveguides populated with synthesized thermal photons. The target qubit, if initially fully excited, reaches a steady-state excited-level population of $5\times10^{-4} \pm 5\times10^{-4}$ (an effective temperature of 23.5 mK) in about 1.6 μs. Our results epitomize how quantum thermal machines can be leveraged for quantum information-processing tasks. They also initiate a path toward experimental studies of quantum thermodynamics with superconducting circuits coupled to propagating thermal microwave fields.

References

[1] Preprint: https://arxiv.org/abs/2305.16710

Figures

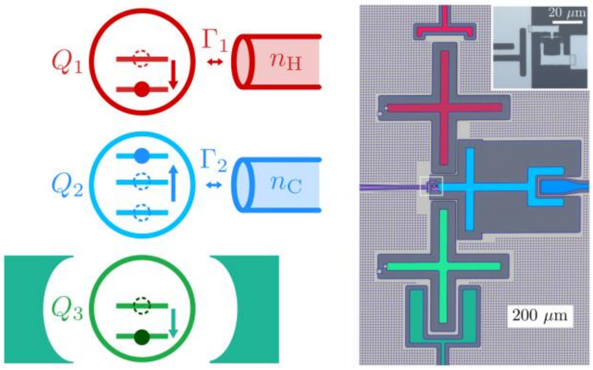

Figure 1: Scheme and implementation of a quantum absorption refrigerator.