QuanTalks

IISc Quantum Technology Initiative (IQTI)
Seminar Series

Thermally driven quantum refrigerator autonomously resets superconducting qubit

Wednesday, 20th December 2023, 4 PM
Physics Auditorium, IISc

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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. Preprint: https://arxiv.org/abs/2305.16710

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Aamir Ali obtained his BSc. degree in Physics (Honors) from St. Xavier's College, Kolkata in 2009. He carried on to the Integrated PhD program in Physics in the Indian Institute of Science, Bangalore. Under the supervision of Prof. Arindam Ghosh, he carried out his PhD work in condensed matter physics in semiconductor heterostructures and bilayer graphene. After obtaining his Ph.D. in 2017, he moved for postdoctoral research with Prof. Dmitri Efetov in the Institute of Photonic Sciences, Spain. There, he learned techniques based on microwave electronics techniques and developed a proof-of-principle calorimeter that performed the first-ever measurement of the electronic heat capacity of graphene. Next, he switched his research field to superconducting quantum circuits after moving to the group of Prof. Simone Gasparinetti in the recently formed Wallenberg Centre for Quantum Technology (WACQT) at Chalmers University of Technology, Sweden. The Centre is dedicated to a 12-year, ~100 million Euros Swedish program to build a quantum computer and increase industrial awareness of the opportunities offered by quantum technology. His focus here is on the development of an emerging field of quantum thermodynamics based on superconducting quantum circuits. It addresses the fundamental physics of how quantum-mechanical effects on thermodynamics; as well as applications such as energy management in quantum technology.

Coffee/Tea @ 3.45PM

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