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Dicke superradiant enhancement of the heat current in circuit QED

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Collective effects, such as Dicke superradiant emission, can enhance the performance of a quantum device. Here, we study the heat current flowing between a cold and a hot bath through an ensemble of N qubits, which are collectively coupled to the thermal baths. We find a regime where the collective coupling leads to a quadratic scaling of the heat current with N in a finite-size scenario. Conversely, when approaching the thermodynamic limit, we prove that the collective scenario exhibits a parametric enhancement over the non-collective case. We then consider the presence of a third uncontrolled {\it parasitic} bath, interacting locally with each qubit, that models unavoidable couplings to the external environment. Despite having a non-perturbative effect on the steady-state currents, we show that the collective enhancement is robust to such an addition. Finally, we discuss the feasibility of realizing such a Dicke heat valve with superconducting circuits. Our findings indicate that in a minimal realistic experimental setting with two superconducting qubits, the collective advantage offers an enhancement of approximately 10% compared to the non-collective scenario

Title

Author

Primary author: ANDOLINA, Gian Marcello

Presenter: ANDOLINA, Gian Marcello