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# Quantum thermodynamics: Heat leaks and fluctuation dissipation

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Quantum thermodynamics focuses on extending the notions of heat and work to microscopic systems, where the concepts of non-commutativity and measurement back-action play a role [1]. Our experimental system consists of one or multiple qubits implemented in the Zeeman sublevels of the ground electronic state of 40Ca+, and the ion register is held in a microstructured Paul trap [2]. Quantum logic gate operations implement coherent dynamics in the multi-particle quantum system. Additionally, we use optical pumping to initialize spin qubits in a statistical mixture of $|0\rangle$ and $|1\rangle$, thus emulating thermal states. We test the principle of passivity to set bounds on system evolution in the following way: we subdivide the register into the system and environment qubits and then reveal the amount of non-unitary evolution of the system qubits by measuring only in the computational basis and without accessing the environment. The concepts of global passivity, and passivity deformation set tighter bounds for detecting such a heat leak [3]. In addition, we apply non-commuting sequential operations on a single spin and observe the resulting work fluctuations, as suggested theoretically [4].

[1] S. Vinjanampathy and J. Anders, Contemporary Physics 57, 545-579 (2016).

[2] J.Hilder et. al., accepted in Physical Review X (2022), arXiv:2102.12047 (2021).

[3] D. Pijn et. al., arXiv:2110.03277v1 (2021).

[4] M. Scandi et. al., Physical Review Research 2 023377 (2020).

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