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Thermodynamics of weakly measured quantum systems

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The laws of thermodynamics classify energy changes for macroscopic systems as work performed by an external driving and heat exchanged with the environment. For quantum systems in contact with an external environment, the very identification of heat and work is a challenge, since work cannot be directly accessed by measurement. Quantum systems continuously monitored by a detector have recently provided a formidable platform to explore energy exchanges with the environment at a quantum level, both theoretically and experimentally.

Here we introduce thermodynamic quantities, heat, and work, along single quantum trajectories of continuously monitored systems based on the identification of the deterministic unitary part (work) and the stochastic non-unitary part (heat) of the evolution. We analyze the consistency of the introduced quantities by showing that they fulfill the second law of thermodynamics in the form of a generalized Jarzynski equality in the presence of tailored quantum feedback [1]. We present the experimental data reporting the detection of the proposed heat and work in superconducting-based setups [2]. Finally, we show that the system-detector information exchange displays non-classical features uniquely due to quantum measurement back-action, which re detected in experiments [3].

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