Measuring stochastic thermodynamics in mesoscopic systems using a quantum work agent

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Non-equilibrium fluctuation theorems (NFTs) relate work performed on a system as its Hamiltonian varies with time, to equilibrium data of the initial and final states. In a classical context the system energy can be directly measured, while a quantum implementation requires the incorporation of a work-agent. We demonstrate that the uncertainty principle imposes inherent quantum limitation on the applicability of the NFT for probing non-trivial mesoscopic systems. We work out the NFT validity regime for the simplest quantum-dot toy model, and discuss future applications.