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Exploring quantum thermodynamics in continuous measurement of superconducting qubits[1]

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The extension of thermodynamics into the realm of quantum mechanics, where quantum fluctuations dominate and systems need not occupy definite states, poses unique challenges. Superconducting quantum circuits offer exquisite control over the environment of simple quantum systems allowing the exploration of thermodynamics at the quantum level through measurement and feedback control. We use a superconducting transmon qubit that is resonantly coupled to a waveguide cavity as an effectively one-dimensional quantum emitter. By driving the emitter and detecting the fluorescence with a near-quantum-limited Josephson parametric amplifier, we track the evolution of the quantum state and characterize the work and heat along single quantum trajectories. By using quantum feedback control to compensate for heat exchanged with the emitter's environment we are able to extract the work statistics associated with the quantum evolution and examine fundamental fluctuation theorems in non-equilibrium thermodynamics.

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