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Fluctuation relations and Maxwell's demon in a circuit QED setup

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The recent progress in information thermodynamics has resolved the paradox of Maxwell's demon and clarified the relationship between the information and the entropy [1]. Its extension to quantum mechanical systems has also attracted much interest, and experimental demonstrations are awaited. Circuit QED systems offer the following tools suitable for investigating the properties of a quantum system coupled with a controlled environment: (i) a well-controlled qubit with a long coherence time, (ii) dispersive readout allowing high-fidelity quantum nondemolition measurement, and (iii) fast feedback control. We first apply the so-called two-measurement protocol (TMP) to a superconducting transmon qubit in a microwave cavity and study how the decoherence affects the nonequilibrium thermodynamic relations [2]. Next, we implement Maxwell's demon in the circuit QED system by introducing a feedback loop and confirm the fluctuation relation including the effect of the information obtained in the feedback process [3]. These results constitute a first step towards quantum thermodynamics in circuit QED systems. [1] J. M. R. Parrondo, J. M. Horowitz, and T. Sagawa, Nature Phys. 11, 131 (2015). [2] J. Pekola *et al.*, Phys. Rev. E 91, 062109 (2015). [3] K. Funo, Y. Murashita, and M. Ueda, New J. Phys. 17, 075005 (2015).