An autonomous quantum machine to measure the thermodynamic arrow of time

J. Monsel[a], C. Elouard[a,b], and A. Auffèves[a]

[a]Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France
[b]Department of Physics and Astronomy, University of Rochester, Rochester, New York 14627, USA

According to the Second Law of thermodynamics, the evolution of physical systems has a preferred direction, that is characterized by some positive entropy production. Here we propose a direct way to measure the stochastic entropy produced while driving a quantum open system out of thermal equilibrium. The driving work is provided by a quantum battery, the system and the battery forming an autonomous machine. We show that the battery's energy fluctuations equal work fluctuations and check Jarzynski's equality. Since these energy fluctuations are measurable, the battery behaves as an embedded quantum work meter and the machine verifies a generalized fluctuation theorem involving the information encoded in the battery. Our proposal can be implemented with state-of-the-art opto-mechanical systems. It paves the way towards the experimental demonstration of fluctuation theorems in quantum open systems.