Stochastic thermodynamics of a particle in a box

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The piston system (particles in a box) is the simplest paradigmatic model in traditional thermodynamics. However, the recently established framework of stochastic thermodynamics (ST) fails to apply to this model system due to the embedded singularity in the potential. We study the ST of a particle in a box by adopting a novel coordinate transformation technique. Through comparing with the exact solution of a breathing harmonic oscillator, we obtain analytical results of work distribution for an arbitrary protocol in the linear response regime and verify various predictions of the fluctuation-dissipation relation. When applying to the Brownian Szilard engine model, we obtain the optimal protocol $\lambda_t = \lambda_0\ 2^t$ for a given sufficiently long total time τ. Our study not only establishes a paradigm for studying ST of a particle in a box but also bridges the long-standing gap in the development of ST [1].

[1] Z. Gong, Y. Lan, H. T. Quan, Phys. Rev. Lett. 117 (2016) 180603.