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Optimally Fast Qubit Reset

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In practice, qubit reset must be operated in an extremely short time, which incurs a thermodynamic cost within multiple orders of magnitude above the Landauer bound. We present a general framework to determine the minimal thermodynamic cost and the corresponding optimal protocol for memory erasure under arbitrary erasure speeds. Our study reveals the divergent behavior of minimal entropy production in the short-time limit depends on the convergence and divergence of the jump operator. There is an inherent trade-off between the minimal required time and the set error probability for the convergent class. Moreover, we find the optimal protocol exhibits general features in the fast-driving regime. To illustrate these findings, we employ fermionic and bosonic baths as examples. Our results suggest that the superOhmic bosonic heat bath is suitable for qubit reset.
Y. Liu, C. Huang, X. Zhang and D. He, Phys. Rev. Lett. 134, 100401(2025)

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