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Inverse thermodynamic uncertainty relation and entropy production

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"Nonequilibrium current fluctuations represent one of the central topics in nonequilibrium physics. The thermodynamic uncertainty relation (TUR) is widely acclaimed for rigorously establishing a lower bound on current fluctuations, expressed in terms of the entropy production rate and the average current. In this study, we focus on an upper bound for the fluctuations, referred to as the inverse thermodynamic uncertainty relation (iTUR). We derive a universal iTUR expression in terms of the entropy production rate for continuous-variable systems governed by over-damped Langevin equations, as well as for discrete-variable systems described by Markov jump processes. The iTUR establishes a no-go theorem prohibiting perpetual superdiffusion in systems with a finite entropy production rate and a finite spectral gap. The divergence of the variance of any current becomes possible only when the spectral gap vanishes or the entropy production rate diverges. As a relevant experimental scenario, we apply the iTUR to the phenomenon of giant diffusion, emphasizing the pivotal roles of the spectral gap and entropy production.

Ref. Vo, Dechant, KS, Phys. Rev. Lett. (2025)"

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