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Duality between dissipation-coherence trade-off and thermodynamic speed limit for noisy oscillations

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We derive two fundamental trade-offs for general stochastic limit cycles in the weak-noise limit based on the thermodynamic uncertainty relation. The first is the dissipation-coherence trade-off, which was numerically conjectured and partially proved by Santolin and Falasco [Phys. Rev. Lett. 135, 057101 (2025)]. This trade-off bounds the entropy production required for one oscillatory period using the number of oscillations that occur before steady-state correlations are disrupted. The second is the thermodynamic speed limit, which bounds the entropy production with the Euclidean length of the limit cycle. These trade-offs are obtained by substituting mutually dual observables, derived from the stability of the limit cycle, into the thermodynamic uncertainty relation. This fact allows us to regard the dissipation-coherence trade-off as the dual of the thermodynamic speed limit.
R. Nagayama, and S. Ito. "Duality between dissipation-coherence trade-off and thermodynamic speed limit based on thermodynamic uncertainty relation for stochastic limit cycles in the weak-noise limit" arXiv:2509.06421

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