

# Uncertainty relation for enzymes, resetting systems, and other processes with irreversible transitions

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The thermodynamic uncertainty relation (TUR) shows that the fluctuations of currents are bounded from below by the inverse entropy production. When one or more transitions are completely irreversible the entropy production diverges, and the TUR becomes non-informative. We show that additional bounds, which mix entropic and dynamic contributions, hold for such processes. Crucially, these new bounds are tighter in the presence of irreversible transitions. A steady-state process with resetting, and a transient first-passage problem are used as examples. We also discuss the connections between the bounds and the Aldous-Shepp bound that is often used in statistical kinetics.

- [1] A. Pal, S. Reuveni, and S. Rahav, Thermodynamic uncertainty relation for systems with unidirectional transitions, *Phys. Rev. Research*, 3, 013273 (2021).
- [2] A. Pal, S. Reuveni, and S. Rahav, Thermodynamic uncertainty relation for first-passage times on Markov chains, *arXiv:2103:16578* (2021).