Macroscopic stochastic thermodynamics

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Equilibrium thermodynamics emerges from equilibrium statistical mechanics as the most likely behavior of a system in the macroscopic limit. Over the last two decades, enormous progress has been achieved in formulating statistical mechanics for small systems operating far-from-equilibrium. The resulting theory is called stochastic thermodynamics. I will show that taking the macroscopic limit of stochastic thermodynamics enables to formulate a nonequilibrium thermodynamics of large systems typically described by nonlinear deterministic dynamics, which can also capture macroscopic fluctuations around it [1]. This macroscopic stochastic thermodynamics gives rise to novel fundamental results (for instance, once can bound nonequilibrium steady state fluctuations using the entropy production along deterministic relaxation trajectories [2]) and enables to recover many classical phenomenological results in macroscopic irreversible thermodynamics within well controlled approximations. It also opens the way to study the energetics of many complex nonlinear phenomena in a broad range of systems such as chemical reaction networks (CRNs), nonlinear electrical circuits, and Potts models.

References

[1] G. Falasco, M. Esposito, Macroscopic stochastic thermodynamics, to appear.
[2] N. Freitas, M. Esposito, Emergent second law for non-equilibrium steady states, Nat. Commun., 13, 5084 (2022).