

Nonthermal resources and fluctuations in nanoscale engine

Wednesday, March 13, 2024 11:00 AM (1h 30m)

Standard thermodynamic machines transform heat into work or vice versa. Macroscopic quantities, like temperatures, quantify the efficiency of their operation. This is different in nanoscale systems—often smaller than the length scales on which thermalisation takes place and where fluctuations can be of the same magnitude as average quantities. In this talk, I will show some properties of nanoelectronic devices, operating as engines, that are unique to the small scales on which they are realized.

I will start by introducing novel relations between charge currents flowing in nanoelectronic conductors and their noise. In contrast to standard fluctuation-dissipation relations, valid in equilibrium, these relations for generic nonequilibrium situations consist in inequalities, setting bounds on the currents that can be obtained given a certain noise level of the signal [1]. This has direct implications on the performance of nanoelectronic engines, complementing recently introduced thermodynamics uncertainty relations [2].

However, noise is not only a nuisance, but noisy resources can be beneficial for the operation of an engine! In the second part of my talk, I will introduce engines working without absorbing heat or work from the resource on average, seemingly violating the second law of thermodynamics [3]. This is possible when the resource has nonthermal properties (namely, it cannot be characterized by a temperature or potential) and requires fluctuations in the input [4].

I will end by giving an outlook on how these unconventional resources could possibly be used in future devices.

[1] L. Tesser and J. Splettstoesser: “Out-of-Equilibrium Fluctuation-Dissipation Bounds”, arXiv:2309.17422

[2] A. C. Barato, U. Seifert: “Thermodynamic Uncertainty Relation for Biomolecular Processes”, *Phys. Rev. Lett.* 114, 158101 (2015)

[3] R. Sánchez, J. Splettstoesser, R. S. Whitney: “Nonequilibrium System as a Demon”, *Phys. Rev. Lett.* 123, 216801 (2019)

[4] M. Acciai, L. Tesser, J. Eriksson, R. Sánchez, R. S. Whitney, J. Splettstoesser “Constraints between entropy production and its fluctuations in nonthermal machines”, *Phys. Rev. B* 109, 075405 (2024)

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