The inevitable cost of precision

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I will discuss recent progress in stochastic thermodynamics for understanding fundamental limits to the temporal precision of processes. The thermodynamic uncertainty relation provides a universal lower bound on the precision a process can achieve for a given energy budget [1]. A variant of this relation allows us to extract from experimental data a model-free upper bound on the efficiency of molecular motors [2]. Likewise, for heat engines, this relation shows that Carnot efficiency at finite power can be reached,in principle, but at the cost of diverging power fluctuations [3]. Persistent coherent oscillations of autonomous biomolecular networks are constrained by the number of states in the network and the driving force [4]. In contrast, in periodically driven systems, coherent subharmonic oscillations can persist forever [5].

[1] Thermodynamic uncertainty relation for biomolecular processes. A. C. Barato and U. Seifert, Phys. Rev. Lett. 114, 158101, 2015.

[2] Universal bound on the efficiency of molecular motors. P. Pietzonka, A. C. Barato, and U. Seifert, J. Stat. Mech., 124004, 2016.

[3] Universal trade-off between power, efficiency and constancy in steady-state heat engines. P. Pietzonka and U. Seifert, Phys. Rev. Lett. 120, 190602, 2018.

[4] Coherence of biochemical oscillations is bounded by driving force and network topology. A. C. Barato and U. Seifert, Phys. Rev. E 95, 062409, 2017.

[5] Subharmonic oscillations in stochastic systems under periodic driving. L. Oberreiter, U. Seifert, and A. C. Barato, arXiv, 1902.01963, 2019.