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Optimal control of microscopic nonequilibrium systems

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Molecular machines are protein complexes that convert between different forms of energy, and they feature prominently in essentially any major cell biological process. A plausible hypothesis holds that evolution has sculpted these machines to efficiently transmit energy and information in their natural contexts, where energetic fluctuations are large and nonequilibrium driving forces are strong. Toward a systematic picture of efficient, stochastic, nonequilibrium energy and information transmission, I address two related fundamental questions in nonequilibrium statistical mechanics: How do we predict the response of molecular-scale soft-matter systems to rapid nonequilibrium perturbations? And how do we identify the perturbations that most efficiently (yet rapidly) carry such a noisy system from one state to another? These abstract theoretical considerations have fairly immediate consequences for the design of single-molecule biophysical experiments, and potential implications for the design principles of energetically efficient yet stochastic molecular machines.

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