BP 16: Stochastic Processes

Time: Wednesday 16:00–17:15 Location: ZEU 260

BP 16.1 Wed 16:00 ZEU 260

Anomalous scaling of nano-pore translocation times for structured RNA molecules — Malcolm McCauley[1], Robert Forties[1], •Ulrich Gerland[2], and Ralf Bundschuh[1] — [1]Department of Physics, Ohio State University — [2]Arnold Sommerfeld Center for Theoretical Physics, LMU München

Translocation through a nano-pore is a new single-molecule technique to probe physical properties of biomolecules. A bulk of theoretical and computational work exists on how the main observable, the time to translocate a single molecule, depends on the length of the molecule for unstructured molecules. Here, we study this question for RNA molecules for which the breaking of the secondary structure is the main barrier for translocation. To this end, we calculate the mean translocation time of single-stranded RNA through an idealized nanopore for many randomly chosen RNA sequences. At zero voltage bias, we find that the typical translocation time depends on the sequence length with a power law, the exponent of which changes as a function of temperature and exceeds the naively expected exponent of two for purely diffusive transport at all temperatures. We rationalize this behavior theoretically.

BP 16.2 Wed 16:15 ZEU 260

Optimal protocols in Stochastic Thermodynamics — •Tim Schmiedl[1], Alex Gomez-Marin[2], and Udo Seifert[1] — [1]II. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart, Germany — [2]Facultat de Fisica, Universitat de Barcelona, Diagonal 647, 08028 Barcelona, Spain

For systems in an externally controllable time-dependent potential, the optimal protocol minimizes the mean work spent in a finite-time transition between two given equilibrium states. We consider three different types of dynamics: overdamped Langevin dynamics, underdamped Langevin dynamics, and purely Hamiltonian dynamics. Surprisingly, the optimal protocol involves jumps for overdamped Langevin dynamics and even delta-type singularities for underdamped Langevin dynamics. These optimal protocols significantly improve free energy calculations via the Jarzynski equality.

For purely Hamiltonian dynamics and harmonic potentials, we show that the optimal protocol is highly degenerate and that even in the limit of short transition times, the optimal work is given by the adiabatic work which is substantially smaller than the work for an instantaneous jump. We also perform numerical calculations for purely Hamiltonian dynamics in an anharmonic quartic potential.

[1] T. Schmiedl and U. Seifert, Phys. Rev. Lett 98, 108301 (2007)
[2] A. Gomez-Marin, T. Schmiedl, and U. Seifert, J. Chem. Phys. 129, 024114 (2008)

BP 16.3 Wed 16:30 ZEU 260

Dynamic length regulation in biological transport systems. — •Louis Reese, Anna Melbinger, and Erwin Frey — Arnold Sommerfeld Center for Theoretical Physics (ASC) and Center for NanoScience (CeNS), Department of Physics, Ludwig-Maximilians-Universität München

Microtubules are highly dynamic filaments that perform a variety of tasks in living cells. At the same time they serve as intracellular highways for molecular motors, which are either transported along those tracks or diffuse in the cytosol [1]. Here we examine mechanisms to regulate microtubule-length through the concentration of motors in the cytosol. It is analyzed how the interplay between density-dependent transport on the tracks, and filament polymerization affects the dynamics of filament length [2]. Employing stochastic simulations complemented by analytic calculus we identify three distinct dynamic regimes: (i) steady growth, (ii) bounded growth and (iii) stationary length. The latter shows interesting intermittent dynamics.

[1] A. Parmeggiani, T. Franosch, E. Frey, Phys. Rev. Lett. 90, 086601 (2003).

[2] V. Varga, J. Helenius, K. Tanaka, A. A. Hyman, T. U. Tanaka and J. Howard, Nat. Cell Biol. 8, 957 (2006)

BP 16.4 Wed 16:45 ZEU 260

Polymerization of actin and cooperative ATP hydrolysis — •Xin Li[1], Jan Kierfeld[2], and Reinhard Lipowsky[1] — [1]MPI of Colloids and Interfaces, Science Park Golm, 14424 Potsdam — [2]TU Dortmund, Fakultät Physik, 44221 Dortmund

Actin polymerization plays an important role in many aspects of cell dynamics. Actin polymerization also involves the hydrolysis of ATP molecules, which takes place within an ATP-rich cap and can be spatially separated from the polymer tip. In this study, we theoretically compare different cooperative mechanisms for the coupling between ATP hydrolysis and actin polymerization and describe their effects on experimentally observable quantities, such as cap length, total hydrolysis rate, and actin filament growth rate.

BP 16.5 Wed 17:00 ZEU 260

Optimal potentials for temperature ratchets — •Florian Berger[2], Tim Schmiedl[1], and Udo Seifert[1] — [1]II. Institut für Theoretische Physik, Universität Stuttgart, 70550 Stuttgart — [2]Max Planck Institute of Colloids and Interfaces, Science Park Golm, 14424 Potsdam

Since the introduction by Feynman, temperature ratchets have served as a model for a microscopic heat engine which operates between two heat baths. More generally, directed transport of an overdamped Brownian particle can be induced along a periodic potential in a spatially periodic temperature profile. With a load force applied to the particle, this setup can perform as a heat engine. The dependence of the current on the potential evokes the question: What is the optimal shape of the potential that maximizes the current and thus the power output of the engine for a given load? Using variational calculus, we determine the optimal potential for a sinusoidal temperature profile analytically up to a numerical root search. We discuss the dependence of the optimal potential on scaled model parameters such as the temperature amplitude and the load force.