DY 10: Brownian motion and transport I

Time: Tuesday 14:00–16:00 Location: HÜL 386

Invited Talk DY 10.1 Tue 14:00 HÜL 386

Self-Dynamics of a Slender Rod — •Thomas Franosch — Arnold Sommerfeld Center for Theoretical Physics (ASC) and Center for NanoScience (CeNS), Department of Physics, Ludwig-Maximilians-Universität München, Theresienstraße 37, D-80333 München, Germany

Rods of high aspect ratio in concentrated suspensions constitute strongly interacting systems with rich dynamics: transport slows down drastically and the anisotropy of the motion becomes arbitrarily large. A general theory for the anisotropic motion of rods in entangled suspensions is a long-standing problem, due to the intricacy of the many-body interaction. We have performed extensive computer simulations for a model system consisting of single needle exploring a disordered planar array of obstacles. For ballistic needles we find an enhancement of diffusion as the density of obstacles increases which may be explained by heuristic scaling argument.

For Brownian needles we measure the intermediate scattering function and find a peculiar power-law decay in the highly entangled regime. This behavior can be explained from the strong coupling of translational and rotational motion within a tube and. We then develop a mesoscopic description of the dynamics down to the length scale of the interparticle distance. Our theory is based on the exact solution of the Smoluchowski-Perrin equation for the unconstrained motion. Employing the measured diffusion coefficients as input parameters we find quantitative agreement with our Brownian dynamics simulations in the dense regime

DY 10.2 Tue 14:30 HÜL 386

Brownian Dynamics with Constraints: An Asymptotic-Expansion Approach — Roman Schmitz and •Burkhard Dünweg — MPI fuer Polymerforschung, Mainz, Germany

We consider the well-known problem of overdamped Brownian motion with holonomic constraints. In the "rigid" case, the constraints are viewed as present even on the underlying short ballistic time scales. Conversely, in the "stiff" case, the Brownian motion is viewed as the long-time limiting behavior of a system whose constrained degrees of freedom are in reality subject to stiff harmonic forces, and therefore "fast". Instead of postulating the limiting equation of motion for this latter case ad hoc, we derive it systematically via a multi-time scale expansion of the Fokker-Planck operator, starting from overdamped dynamics for both "slow" and "fast" degrees of freedom.

DY 10.3 Tue 14:45 HÜL 386

Brownian motion in confined geometries – the role of entropic barriers — •Gerhard Schmid, P. Sekhar Burada, and Peter Hänggi — Institut für Physik, Universität Augsburg, D-86135 Augsburg

For particles undergoing biased Brownian motion in static media enclosed by confining geometries, transport exhibits intriguing features such as (i) a decrease of nonlinear mobility with increasing temperature or, also, (ii) a broad excess peak of the effective diffusion above the free diffusion limit [1,2]. These paradoxical aspects can be understood in terms of entropic contributions resulting from the restricted dynamics in phase space. Accordingly, bottlenecks result in *entropic barriers* which, however, exhibit a distinct temperature behavior from that observed for *energetic barriers*. The use of a time-dependent driving then causes Stochastic Resonance, thus demonstrating an anomalous signal amplification in systems possessing entropic barriers [3].

[1] D. Reguera, G. Schmid, P. S. Burada, J. M. Rubi, P. Reimann, and P. Hänggi, Phys. Rev. Lett. **96**, 130603 (2006).
[2] P. S. Burada, P. Hänggi, F. Marchesoni, G. Schmid and P. Talkner, ChemPhysChem (2009), DOI: 10.1002/cphc.200800526.
[3] P. S. Burada, G. Schmid, D. Reguera, M. H. Vainstein, J. M. Rubi, and P. Hänggi, Phys. Rev. Lett. **101**, 130602 (2008).

DY 10.4 Tue 15:00 HÜL 386

Dynamics of a Brownian circle swimmer — •Sven van Teeffelen and Hartmut Löwen — Institute for Theoretical Physics II: Soft Matter, Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf

Self-propelled particles move along circles rather than along a straight line when their driving force does not coincide with their propagation direction. Examples include confined bacteria and spermatozoa, catalytically driven nanorods, active, anisotropic colloidal particles and vibrated granulates. Using a non-Hamiltonian rate theory and computer simulations, we study the motion of a Brownian "circle swimmer" in a confining channel. A sliding mode close to the wall leads to a huge acceleration as compared to the bulk motion, which can further be enhanced by an optimal effective torque-to-force ratio.

DY 10.5 Tue 15:15 HÜL 386

Rods in the smectic phase: 1-D Brownian diffusion in a periodic potential — •Pavlik Lettinga[1] and Eric Grelet[2] — [1]Forschungszentrum Jülich, Jülich, Germany — [2]CRPP-CNRS, Pessac, France

We report the direct visualization at the scale of single particles of mass transport between smectic layers, also called permeation, in a suspension of rodlike viruses. We show that this diffusion effectively can be described by 1-D diffusion of a Brownian particle in a periodic potential. We compare this diffusion with diffusion of rods in the isotropic and nematic phase.

DY 10.6 Tue 15:30 HÜL 386

Giant diffusion of active Brownian particles — •Benjamin Lindner and Ernesto M. Nicola — Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany

We study analytically the diffusion coefficient of an active Brownian particle with a spatial asymmetry. We demonstrate the existence of a critical force or, more generally, of a critical asymmetry that separates parameter regimes of giant diffusion from those with reliable directed transport. We derive a condition for the critical asymmetry by means of an exact expression for the diffusion coefficient and by a simplified discrete picture. A critical asymmetry, as predicted by the simple model, is also found in a detailed model of coupled molecular motors displaying bidirectional motion. Refs.: Lindner & Nicola Eur. Phys. J. ST 157, 43 (2008); Lindner & Nicola Phys. Rev. Lett. 101, 190603 (2008).

DY 10.7 Tue 15:45 HÜL 386

Performance Tests for Techniques that measure long-range Persistence in Time Series — •Annette Witt[1,2] and Bruce D. Malamud[2] — [1]Max-Planck-Institute for Dynamics and Self-organization, Bernstein Center for Computational Neuroscience Göttingen, Göttingen, Germany — [2]Department of Geography, King's College London, United Kingdom

Many time series of complex systems exhibit long-range persistence, where the power spectral density scales with a power law. The corresponding scaling exponent beta characterizes the "strength" of persistence. We compare four common techniques for quantifying long-range persistence in time series: (a) Power-spectral analysis, (b) Detrended fluctuation analysis, (c) Semivariogram analysis, and (d) Rescaled-Range (R/S) analysis. To evaluate these methods, we construct synthetic fractional noises with lengths between 512 and 4096, different persistence strengths, and different distributions (Gaussian, log-normal, Levy). We empirically find: (i) Power-spectral analysis and detrended fluctuation analysis are unbiased across all beta, although anti-persistence is over-estimated for asymmetric distributed time series; (ii) Detrended Fluctuation Analysis has larger random errors than power-spectral analysis, in particular for non-Gaussian signals. (iii) Semivariograms are appropriate for signals with long-range persistence strength between 1.0 and 2.8; it has large confidence intervals and systematically underestimates beta for asymmetric distributed time series in this range; (iv) Rescaled-Range Analysis is only accurate for beta of about 0.7, and systematically under- or over-estimates for other values.