DY 33: Brownian Motion, Stochastic Processes, Transport I

Time: Thursday 14:00–17:00 Location: HÜL 186

DY 33.1 Thu 14:00 HÜL 186

Dynamics of self-assembly of flower-shaped magnetic colloidal clusters — •Ayan Ray, Saeedeh Aliaskarisohi, and Thomas M. Fischer — Institute of Physics, Universität Bayreuth, Bayreuth 95440, Germany

In a static magnetic field paramagnetic and nonmagnetic colloids immersed in a ferrofluid self-assemble into fluctuating colloidal flowers. Adsorption and desorption of nonmagnetic petals to larger paramagnetic cores and changes in the petal conformation around the paramagnetic core induce a fluctuating dynamics. We track the motion of colloidal petals on the paramagnetic core. Adsorption and desorption of petals occur on a larger time scale than the rotational diffusion of the petals. Magnetic dipole interactions split the motion of the petals into different modes of rotational diffusion. Modes of rotational diffusion that change the petal conformation are suppressed compared to the conformation invariant rotational diffusion of all petals. The suppression of higher modes of rotational diffusion results in a subdiffusive dynamics of the individual petals.

DY 33.2 Thu 14:15 HÜL 186

Escape rate of an active Brownian particle — •P. Sekhar Burada and Benjamin Lindner — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study the dynamics of an active Brownian particle in a spatial cubic potential, in particular, its rate of escape over the potential barrier. Here, we consider an effective nonlinear friction function, which acts as an energy pump for the Brownian particle, and study the escape dynamics of the particle by varying the amplitude of spatial cubic potential. In contrast to the Arrhenius law for the escape rate found for a normal ("passive") Brownian particle, the escape rate of an active particle shows a non-monotonic dependence on the strength of fluctuations. We explain the stochastic mechanism for this remarkable effect.

DY 33.3 Thu 14:30 HÜL 186

Quantum master equation in phase space applied to the Brownian motion in a tilted periodic potential — •William Coffey[1], Yuri Kalmykov[2], Sergey Titov[3], Liam Cleary[4], and William Dowling[1] — [1]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [2]Laboratoire de Mathématiques, Physique et Systèmes, Université de Perpignan, 52, Avenue de Paul Alduy, 66860 Perpignan Cedex, France — [3]Institute of Radio Engineering and Electronics, Russian Acad. Sci., Vvedenskii Square 1,Fryazino 141190, Russia — [4]Massachusetts Institute of Technology

Quantum effects in the Brownian motion of a particle in a tilted cosine potential are treated in the high temperature and weak bath-particle coupling limit using the semiclassical master equation for the time evolution of the Wigner distribution function in phase space proposed by Coffey et al. [PCCP 9, 3361, 2007]. The differential recurrence relation generated from the quantum master equation by expanding the distribution function in Fourier series are solved using matrix continued fractions yielding both the time-independent and the time-dependent periodic solutions. The time-independent periodic solution is of interest in calculating quantum effects in the dc current-voltage characteristic of a Josephson junction including the capacitance, while the time-dependent periodic solution governs dynamical properties of the junction in the locked state such as the impedance, etc. In the limit of high damping the results reproduce those yielded by the semiclassical Smoluchowski equation [W. Coffey et.al, PRE 78, 031114, 2008].

DY 33.4 Thu 14:45 HÜL 186

Langevin equation of a system nonlinearly coupled to a heat bath — •Mykhaylo Evstigneev and Peter Reimann — Universität Bielefeld, 33615 Bielefeld, Deutschland

We derive the generalized Langevin equation for a system in contact with a heat bath. In contrast to the previous treatments focusing on linear system-bath coupling, we consider a general case where the corresponding interaction potential has an arbitrary functional form, but is weak in comparison to the coupling between the bath particles. The validity of our results is demonstrated on two simple models.

DY 33.5 Thu 15:00 HÜL 186

Feedback-controlled transport in an interacting colloidal system — •Ken Lichtner and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

We consider a non-equilibrium system of interacting colloidal particles driven by a constant tilting force through a periodic, symmetric "washboard" potential. As a framework for solving the equation of motion for the time-dependent density profile, we employ the Dynamical Density Functional Theory (DDFT)[1], where the microscopic particle interactions enter via a free energy functional. In [2] we demonstrate that, despite pronounced spatio-temporal correlations, the particle current can be reversed by adding suitable feedback control terms, similar to what has been found for single-particle transport[3]. We explore two distinct control protocols with time delay, focussing on either the particle positions or the density profile. Our study shows that the DDFT is an appropriate framework to implement time-delayed feedback control strategies widely used in other fields of nonlinear physics.

[1] A. J. Archer and R. Evans, J. Chem. Phys., 121 (2004) 4246.
[2] K. Lichtner and S. H. L. Klapp, Europhys. Lett., accepted.
[3] D. Hennig, Phys. Rev. E, 79 (2009) 041114.

DY 33.6 Thu 15:15 HÜL 186

Entropic transport in energetic potentials — P. Sekhar Burada[1], Yunyun Li[2], Wolfgang Riefler[2], and •Gerhard Schmid[2] — [1]MPI für Physik komplexer Systeme, Germany — [2]Universität Augsburg, Germany

We study the transport of point size particles in micro-sized two dimensional periodic channels [1]. The channels exhibit periodically varying cross sections. The particles are subjected to a constant external force acting alongside the direction of the longitudinal channel axis and a varying force stemming from a periodic substrate potential. While particle transport in tilted periodic potentials is facilitated by noise, the transport through pores with periodically varying cross-section worsens with increasing noise level, i.e. increasing temperature. The competition between the noise-assisted propagation for energetic potentials and the hampered transport in confined structures leads to a striking, non-monotonic behavior which sensitively depend on the phase lag of the periodic channel structure and the periodic potential. By controlling this phase lag the symmetry could be broken and rectification observed.

[1] P.S. Burada, Y. Li, W. Riefler, G. Schmid, Chem.Phys. **375**, 514 (2010).

15 min. break.

DY 33.7 Thu 15:45 HÜL 186

Nano-Mechanical Single-Electron Devices — •Alex Croy and Alex Eisfeld — MPI-PKS Dresden

The fabrication and utilization of nanoscale machines and devices is one of the great promises of the 21st century. In particular, so-called *nanoelectromechanical systems* provide intriguing possibilities for applications beyond common paradigms. The involvement of mechanical parts promises increased robustness, low power-consumption and higher operating temperature compared to conventional devices. One paradigm in this regard is the *nanomechanical single-electron transistor (NEMSET)* proposed by Gorelik et al. which can exhibit mechanically assisted charge transport.

In this context, we present theoretical results for two new nanomechanical single-electron devices, which promise interesting applications. The first device consists of two couples NEMSETs and can be used for storage of information. The second device is a single-electron rotor, which generalizes the NEMSET concept and can act as a charge pump.

DY 33.8 Thu 16:00 HÜL 186

Diffusion of active Brownian particles with coloured angular noise — •Christian Weber and Lutz Schimansky-Geier — Department of Physics, Humboldt Universität zu Berlin, Germany

Motivated by the motion of biological agents we introduce a model of a self-propelled particle with coloured angular noise given by an Ornstein-Uhlenback process (OUP). The consideration of OUP driven noise leads to trajectories which are reminiscent of searching behaviour of animals. We derive analytical results for the angular correlation function and the mean square displacement (MSD). The impact of the correlation time of the OUP on the MSD is discussed for different scalings of the noise intensity in the OUP. A possible connection to polymer physics (worm-like chains) will be briefly discussed.

DY 33.9 Thu 16:15 HÜL 186

Brownian motion with active fluctuations — •Pawel Romanczuk and Lutz Schimansky-Geier — Department of Physics, Humboldt Universität zu Berlin, Germany

We analyze dynamics of particles with fluctuating velocity and orientation in two spatial dimensions. We distinguish passive (e.g. thermal fluctuations) and active fluctuations which emerge in active systems far from equilibrium as for example living organisms or chemically driven colloids. We derive analytical expressions for the speed and velocity distributions for generic models of (active) Brownian particles in two spatial dimensions. The presence of active fluctuations already for simple Stokes friction results in speed and velocity distributions which differ from the classical Maxwell distribution. Active Gaussian fluctuations lead to speed distributions increasing as $\sim |v|^\alpha$ with $\alpha < 1$ at small speeds $|v| \ll 1$ which results in a divergence of the corresponding stationary Cartesian velocity distributions at the origin. Finally we show that such a behavior occurs also for non-Gaussian active fluctuations (shot noise).

Topical Talk DY 33.10 Thu 16:30 HÜL 186

Motion States in Intracellular Transport — •Doris Heinrich — Faculty of Physics and Center for NanoScience (CeNS), Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz 1, 80539 München, Germany

The living cell's cytoskeleton is a fascinating active network, in which diffusion is intercepted by distinct phases of directed transport. To dissect temporal phases (i) of active, directed motion of a tracer particle along a cellular filament and (ii) motion in the diffusive regime, a time-resolved statistical mean-squared-displacenment (MSD) analysis was applied. In living amoeba, the distribution of active lifetimes for an intracellular particle, moving along microtubules via ATP-driven biomotors, is found to decay exponentially with a characteristic lifetime of about t=0.5s [1]. However in motor neurons, cellular vesicles show very efficient directed transport for large distances, whereas inserted non-functionalized nanoparticles mostly undergo subdiffusion [2]. To investigate the time-dependent contributions of cytoskeletal components on diffusive motion states in the crowded cellular interior, a local, lag-time dependent MSD analysis was employed. Cellular finetuning from Brownian to subdiffusive motion could be extracted, which enables effective interplay of intracellular molecules on the nanoscale. This active actin-microtubule interplay is not only important for intracellular transport, but also contributes to active cellular stability and other cell functions, like cellular migration [3].

[1] PRL101:248103(2008) [2] ChemPhysChem10:2884(2009)
[3] Annu.Rev.Condens.MatterPhys.1:257(2010)