DY 7: Stochastic processes, brownian motion, and transport

Time: Tuesday 9:30–12:45 Location: H46

Topical Talk DY 7.1 Tue 9:30 H46

Directing Brownian motion: Negative mobility and beyond — •Ralf Eichhorn — Nordic Institute for Theoretical Physics (Nordita), Stockholm, Sweden

The movement of a Brownian particle in a symmetric, periodic potential landscape under the influence of external driving forces is considered, and the response to a small static perturbation is studied. We show that quite unusual transport properties may arise. Specifically, average particle motion opposite to the static force (negative mobility) is observed. An intuitive explanation of the underlying physical mechanism, experimental realizations, and generalizations of this effect are presented.

DY 7.2 Tue 10:00 H46

Colloidal Transport Through Micro porous Media — •Yujie Li[1,2], Christian Scholz[2], and Clemens Bechinger[1,2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, 70569 Stuttgart, Germany — [2]2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

The transport properties of colloidal particles were studied on a single particle level in quasi two-dimensional disordered micro porous structures with a temporal resolution of 2 ms and spatial resolution of 0.3 μm. Different hydrodynamic dispersion mechanisms, such as Taylor dispersion, mechanical dispersion, and hold-up of particles in stagnant regions, were visualized in real space. In agreement with theoretical predictions, we find the mean square displacement (MSD) to increase with time t according to a power law $\langle X^2 \rangle \sim t^\alpha$, where α varies for different regimes. From the crossover between ballistic ($\alpha = 2$) and super diffusive ($\alpha > 1$) transport, the characteristic length ξ of the structures was estimated and compared with the structural correlation length ξ_0 defined in the flow direction. By plotting the average velocities as a function of the pressure drop, the permeabilities of different structures were derived and studied in accordance with the pore size.

DY 7.3 Tue 10:15 H46

Semiclassical treatment of a Brownian ratchet using the quantum Smoluchowski equation — •Liam Cleary[1], William T. Coffey[1], Yuri P. Kalmykov[2], and Serguey V. Titov[3] — [1]Trinity College Dublin, Ireland — [2]Université de Perpignan, France — [3]Russian Academy of Sciences, Russia

Quantum effects in the noninertial Brownian motion of a particle in a one-dimensional ratchet potential are treated in the high temperature and weak bath-particle coupling limit by solving a quantum Smoluchowski equation for the time evolution of the Wigner function in configuration space. In particular, an analytical expression for the stationary average drift velocity for constant driving forces is presented including quantum corrections to any order in Planck's constant. The corresponding frequency response is determined using continued fractions in both the linear approximation holding for small ac driving amplitude and in the nonlinear regime for arbitrary driving amplitude exhibiting pronounced ac induced frequency dependence of the dc component of the average drift velocity. Moreover, Shapiro steps are apparent in the dc characteristics for strong ac driving just as in the dc current-voltage characteristics of a point Josephson junction.

DY 7.4 Tue 10:30 H46

Steering the potential barriers: energetic ↻ entropic — •P. Sekhar Burada[1], Peter Hänggi[2], and Gerhard Schmid[2] — [1]MPI for the Physics of Complex Systems, Dresden, Germany — [2]University of Augsburg, Augsburg, Germany

We propose a new mechanism to alter the nature of the potential barrier when a biased Brownian particle under goes a constrained motion in narrow, periodic channels [1,2]. By rotating the external bias, the nature of the potential barrier changes from energetic to purely entropic which in turn effects the diffusion process inside the system. At an optimum angle of the bias, the average particle current exhibits a resonance-like peak. Moreover, the enhancement of the effective diffusion coefficient is efficiently controlled by the rotation angle. This mechanism enables the proper design of channel structures for transport of molecules and small particles. The approximative analytical predictions have been corroborated with precise Brownian dynamic simulations of the full dynamics.

[1]. P.S. Burada, P. Hänggi, F. Marchesoni, G. Schmid, and P. Talkner, *ChemPhysChem* **10**, 45 (2009).
[2]. D. Reguera, G. Schmid, P.S. Burada, J.M. Rubí, P. Reimann, and P. Hänggi, Phys. Rev. Lett. **96**, 130603 (2006).

DY 7.5 Tue 10:45 H46

Deterministic Josephson vortex ratchet made of intrinsic junctions — •E. Goldobin[1], H. B. Wang[2], B. Y. Zhu[3], C. Gürlich[1], M. Ruoff[1], S. Kim[2], T. Hatano[2], B. R. Zhao[3], Z. X. Zhao[3], D. Koelle[1], and R. Kleiner[1] — [1]Physikalisches Institut – Experimentalphysik II, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany — [2]National Institute for Materials Science, Tsukuba 3050047, Japan — [3]National Laboratory for Superconductivity, Institute of Physics, and Beijing National Laboratory for Condensed Matter Physics, Chinese Academy of Sciences, Beijing 100080, China

We demonstrate the operation of a deterministic fluxon ratchet made of a stack of 30 intrinsic Josephson junctions strongly coupled with each other. The ratchet has the shape of a gear with 20 asymmetric teeth (periods). It produces a rectified voltage of about 100 μV at a 12 GHz driving frequency. The effect of coupling between intrinsic junctions, has been studied within the framework of the 2D coupled sine-Gordon equations. We show that this type of device may provide record values of rectified voltage and others figures of merit.

DY 7.6 Tue 11:00 H46

The random phase property and the Lyapunov spectrum — •Rudolf A Römer[1] and Hermann Schulz-Baldes[2] — [1]Department of Physics and Centre for Scientific Computing, University of Warwick, Coventry CV4 7AL, UK — [2]Department Mathematik, FAU Erlangen-Nuernberg, Germany

A random phase property establishing a link between quasi-one-dimensional random Schrodinger operators and full random matrix theory is advocated. Briefly summarized it states that the random transfer matrices placed into a normal system of coordinates act on the isotropic frames and lead to a Markov process with a unique invariant measure which is of geometric nature. On the elliptic part of the transfer matrices, this measure is invariant under the full hermitian symplectic group of the universality class under study. While the random phase property can up to now only be proved in special models or in a restricted sense, we provide strong numerical evidence that it holds in the Anderson model of localization. A main outcome of the random phase property is a perturbative calculation of the Lyapunov exponents which shows that the Lyapunov spectrum is equidistant and that the localization lengths for large systems in the unitary, orthogonal and symplectic ensemble differ by a factor 2 each. In an Anderson-Ando model on a tubular geometry with magnetic field and spin-orbit coupling, the normal system of coordinates is calculated and this is used to derive explicit energy dependent formulas for the Lyapunov spectrum.

DY 7.7 Tue 11:15 H46

Diffusion and Extreme-Value Statistics — •Julien Randon-Furling — AG Rieger, Theoretische Physik, Univ. Saarland, Germany

The ubiquity of Brownian motion in both "natural" and "man-made" contexts (from particle diffusion to financial markets), together with its mathematical status as fundamental stochastic process, makes it of particular interest for theoretical physicists.

We shall review a number of new results involving Brownian motion, obtained using standard tools from statistical physics and linked to the statistics of extreme values. In particular, we will show how one can derive exact results on the geometry of the diffusion surface in 2 and 3 dimensions. These can be extended to so-called anomalous diffusion and other processes, eg partly Brownian - partly ballistic motion or collective motion, as we shall see in dimension 1 and/or 2.

DY 7.8 Tue 11:30 H46

Record statistics in improving populations — •Gregor Wergen and Joachim Krug — Institut für Theoretische Physik, Universität zu Köln

Record breaking events are relevant in many different areas of research. For instance in climatology records are important events which are of-

ten mentioned in current media coverage. Also in biology, economy or sports, records can be interesting. In most cases where records appear there is always the question if a record occurred just by chance or because of a real improvement. We considered the statistics of record-breaking events for random variables from distributions with an increasing mean value. While the statistics of records in time-independent and uncorrelated time-series is understood quite well, there are a lot of open questions for record events from distributions that are not-stationary. We derive a general expression for the probability for a record-breaking event in the case of an underlying distribution with a small linear drift. This expression can be evaluated for various elementary distributions. We compared our results to numerical simulations. The results are important for applications in climatology, where they can be used to predict the increase in the number of record events due to global warming.

DY 7.9 Tue 11:45 H46

Langevin description of subordinated Brownian motion in the presence of external potentials — •Stephan Eule[1] and Rudolf Friedrich[2] — [1]Max-Planck-Institut fuer Dynamik und Selbstorganisation, Goettingen — [2]Institut fuer Theoretische Physik, Westfaelische-Wilhelms-Universitaet Muenster

The role of external forces in systems exhibiting anomalous diffusion is discussed within the framework of Langevin equations. Since there exist different possibilities to include the effect of an external field the concept of biasing and decoupled external fields is introduced. This leads to two different forms of time-fractional Fokker-Planck equations. Complementary to the established Langevin equations for subordinated Brownian motion in a time-dependent external force-field by Magdziarz et al. the Langevin formulation of anomalous diffusion in a decoupled time-dependent force-field is derived.

DY 7.10 Tue 12:00 H46

Intrinsic common noise in a system of two coupled Brusselators — •Amitabha Nandi and Benjamin Lindner — Max-Planck Institut für Physik komplexer Systeme, Nöthnitzer Str. 38 01187 Dresden, Germany.

We investigate the effect of coupling two chemical subsystems through diffusion of chemical species. Such coupling schemes have been studied before at the level of macroscopic rate equations. Here we consider the Langevin description of the actual microscopic dynamics and show that diffusive coupling gives rise to a common noise term along with the elastic interaction. This term contributes negative or positive correlations thereby changing the total correlation between the two systems. As a model example, we study two diffusively coupled Brusselator systems. We show that depending on the dynamical regime, the intrinsic common noise due to coupling affects total correlation significantly.

DY 7.11 Tue 12:15 H46

Thermally activated fragmentation in a simple polymer model — •Simon Fugmann and Igor M. Sokolov — Institut für Physik, Humboldt-Universität zu Berlin, Newtonstraße 15, 12489 Berlin, Germany

We consider the thermally activated fragmentation of a homopolymer chain. In our simple model the dynamics of the intact chain is a Rouse one until a bond breaks and bond breakdown is considered as a first passage problem over a barrier to an absorbing boundary. Using the framework of the Wilemski-Fixman approximation we calculate activation times of individual bonds for free and grafted chains. We show that these times crucially depend on the length of the chain and the location of the bond yielding a minimum at the free chain ends. Based on these results we discus the effect of spacer molecules in polymer rupture experiments performed at a constant loading rate.

DY 7.12 Tue 12:30 H46

Power-law distributions and 1/f noise from nonlinear stochastic differential equations — •Bronislovas Kaulakys, Vygintas Gontis, and Julius Ruseckas — Institute of Theoretical Physics and Astronomy, Vilnius University, A. Gostauto 12, LT-01108 Vilnius, Lithuania

Power-law distributions of spectra, including $1/f^\beta$ noise, and scaling behavior in general are ubiquitous in physics and in many other fields. We consider a class of nonlinear stochastic differential equations, giving the power-law behavior of the spectra in any desirably wide range of frequency [1, 2]. Here the power-law behavior of spectrum is derived directly from the stochastic differential equations. The derivation expands the class of equations generating $1/f^\beta$ noise, provides further insights into the origin of $1/f^\beta$ noise and reveals that the power spectrum may be represented as a sum of the Lorentzian spectra [3].

[1] B. Kaulakys, J. Ruseckas, V. Gontis and M. Alaburda, Physica A **365**, 217 (2006).

[2] B. Kaulakys and M. Alaburda, J. Stat. Mech. P02051 (2009).

[3] J. Ruseckas and B. Kaulakys (to be published).