DY 31: Anomalous Diffusion

Time: Thursday 15:00–16:45 Location: H48

DY 31.1 Thu 15:00 H48

A self-consistent theory for the localization transition in the Lorentz model — •Simon Lang[1], Teresa Behl[2], Felix Höfling[3], and Thomas Franosch[1] — [1]Institut für Theoretische Physik, Erlangen-Nürnberg — [2]Fakultät für Physik, LMU München — [3]Institut für Theoretische Physik IV, Universität Stuttgart; MPI für Intelligente Systeme, Stuttgart

The reference system for transport in porous media is the Lorentz model, which mimics the dynamics of a particle in a heterogeneous environment of obstacles randomly distributed in space. For a tracer particle obeying brownian repeated collisions with a single obstacle is sufficient to explain the persistent correlations. Therefore for brownian motion the low-density expansion already reveals the onset of long-time tails for the velocity-auto-correlation function (VACF) in next to leading order in density [1]. Here, we use the results of the low-density approximation to formulate a self-consistent theory for the VACF for brownian dynamics of a tracer particle in two dimensions. For low densities, the theory reduces to the exact expansion of Ref. [1], for higher density a consistent diffusion-localization transition is predicted at an obstacle density, which is close to the percolation threshold found for simulations in two dimensions. We find asymptotic scaling laws in the VACF, which are persistent as one approaches the localization transition, as well as long-time tails within the diffusive regime originating from repeated scattering processes.

[1] T. Franosch, F. Höfling, T. Bauer and E. Frey J. Chem. Phys. 375 (2010).

DY 31.2 Thu 15:15 H48

Subdiffusive exciton motion in systems with heavy-tailed disorder — •Sebastiaan M. Vlaming[1,2,3], Alexander Eisfeld[1], Victor A. Malyshev[2], and Jasper Knoester[2] — [1]Max Planck Institute for Physics of Complex Systems, Dresden, Germany — [2]University of Groningen, Groningen, The Netherlands — [3]Massachusetts Institute of Technology, Cambridge, USA

The optical and excitation transport properties of many systems, such as molecular aggregates, photosynthetic complexes and organic photovoltaics, are determined by the collective properties of the relevant excitations, which are strongly influenced by interactions with their environment. In modeling the behavior of these collective excitations in a disordered environment, one conventionally often considers model parameters as stochastic quantities with Gaussian distributions. However, it has been suggested [1] that the limitation to Gaussian distributions is not necessarily the best choice, and novel effects such as exchange broadening and anomalous exciton localization have been shown to be possible when generalizing to the wider class of Lévy distributions. In this study, we investigate the excitation dynamics in such Lévy disordered systems, where we consider molecular aggregates as a model system. It is shown that the exciton dynamics changes qualitatively when generalizing to Lévy disorder distributions, leading to sub-diffusive (i.e. less mobile than diffusive) behavior of the exciton transport.

[1] AE, SMV, VAM, and JK, Phys. Rev. Lett. 105, 137402 (2010) [2] SMV, AE, VAM, and JK, to be submitted

DY 31.3 Thu 15:30 H48

Spatial-temporal velocity autocorrelation function for random walks. — •Vasily Zaburdaev[1], Sergey Denisov[2], and Peter Hänggi[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Institute of Physics, Augsburg University, Augsburg, Germany

In this work we borrow the concept of spatial-temporal velocity autocorrelation function from the worlds of many-particle systems and fluid dynamics and adopt it for continuous-time random walks. Assuming that at any instant of time a diffusing particle has a well-defined velocity, we pose a question whether it is possible for the particle to remember its initial velocity at some later time and some distance from the starting point. Results are already remarkable for the regime of standard diffusion and exhibit even more rich behavior as diffusion becomes anomalous. We show that for normal diffusion and superdiffusion regimes with sub-ballistic scaling, spatial-temporal velocity autocorrelation function is equivalent to the time derivative of the particle density. As diffusion becomes faster, correlations decay slower in time and might become comparable to the density itself. It is the coupling of displacement and time via a random walker's velocity that makes a particle to remember its initial velocity far away from the starting point. Spatial-temporal velocity autocorrelation function is an extension of the conventional temporal correlation function for a single particle process and, therefore, provides a new insight into the complex transport phenomena that should find its application in various real world systems.

DY 31.4 Thu 15:45 H48

Distinguishing Between Different Subdiffusive Scenarios. — •Felix Thiel and Igor Sokolov — Institut für Physik der Humboldt-Universität zu Berlin, Deutschland

Subdiffusion can be observed in many theoretical and experimental situations, for instance with proteins diffusing in biological cells or with ion channels moving on the cell membrane. Although one may often be sure, that the process is truly subdiffusive, it is not always clear which physical mechanisms give rise to this behaviour. In particular it is necessary to develop techniques that seperate ergodic and non-ergodic (f.e. ageing) parts of such a process. In this talk, we want to present a quantity, suitable for disorder induced subdiffusion, which is sensitive on the kind of disorder, i.e. structural or energetic disorder. We will present some easy theoretical predictions for this so called fundamental exponent and apply it to some pet models.

DY 31.5 Thu 16:00 H48

Anomalous diffusion in two- and three-dimensional polymer melts — •Hendrik Meyer, Jean Farago, and A.N. Semenov — Intitut Charles Sadron, CNRS UPR22, 67034 Strasbourg, France

Polymers in the melt are known to exhibit subdiffusive monomer dynamics which, for unentangled chains, is well described by the Rouse model. Experiments and simulations have shown that the center of mass of a chain exhibits also subdiffusive behavior, a feature which is not contained in the Rouse model. This feature found recently an unexpected explanation: hydrodynamic interactions are still present in polymer melts and their combination with the viscoelastic properties of the melt explain the observed behavior [1]: there is a short superdiffusive regime followed by subdiffusion until the chain relaxation time. We have now developed the theory of visco-hydrodynamic interactions (VHI) for two-dimensional melts where the superdiffusive regime is strongly enhanced. The theory also takes into account finite-box size effects which strongly modify two-dimensional simulation data. This leads to complex anomalous dynamics which cannot be described by simple power laws [2].

J. Farago et al. Phys. Rev. Lett. **107**, 178301 (2011); PRE **85**, 051806 (2012); H. Meyer and A.N. Semenov, Phys. Rev. Lett. accepted (2012).

DY 31.6 Thu 16:15 H48

Geometric properties of continuous time random walks — •Mirko Lukovic, Theo Geisel, and Stephan Eule — MPI for Dynamics and Self-organization, Goettingen, Germany

We investigate the geometric properties of two-dimensional continuous time random walks. In particular, we determine analytical expressions for the time-evolution of the average perimeter and area of convex hulls of non-Markovian processes such as subordinated random walks and Lévy flights. A convex hull is the minimum convex polygon enclosing a set of monitored points and it proves to be very useful when it comes to estimating the home-range of foraging animals.

DY 31.7 Thu 16:30 H48

Oriented Particles in Porous Media — •Prehl Janett[1], Haber René[1,2], Hoffmann Karl Heinz[1], and Herrmann Heiko[2] — [1]TU Chemnitz, Institut für Physik, Chemnitz, Deutschland — [2]Center for Nonlinear Studies, Institute of Cybernetics at Tallinn University of Technology, Tallinn, Estonia

Diffusion in porous media is a long studied topic. The usual modeling applies point particles without any structure. In this presentation we introduce particles, exhibiting a spatial extension and an orientation, that diffuse in porous media represented by a Sierpinski carpet model. Due to the properties of the applied particles, they interact with their surrounding, i.e. they might get stuck in parts of the structure. Therefore we modeled a new move class for oriented particles based on the blind ant algorithm. We present the obtained result and we discuss the following upcoming questions: How do the oriented particles move within the porous media? Does the transport of these particles follow the same laws as point particles do? If there are differences, are these only local effects or can they also be observed in the over all behavior? Do we obtain different exponents for the mean squared displacement (MSD) or do we even get a new functional dependence for the MSD?