DY 22: Anomalous Diffusion (joint session DY/BP)

Time: Tuesday 14:00–15:30 Location: H47

DY 22.1 Tue 14:00 H47

Diffusion and subdiffusion of interacting particles on comblike structures — •Pierre Illien[1], Olivier Bénichou[2], Gleb Oshanin[2], Alessandro Sarracino[2], and Raphaël Voituriez[2] — [1]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, UK — [2]Laboratoire de Physique Théorique de la Matière Condensée, Université Pierre-et-Marie-Curie, Paris, France

The subdiffusive motion of tracers in crowded media, e.g., biological cells, is widespread, and has motivated a large amount of theoretical work related to diffusion in complex media. Comblike structures have received a particular interest as they constitute minimal models of systems with geometrical constraints. Here, we investigate the effect of excluded-volume interactions on tracer diffusion on such lattices.

We study the dynamics of a tracer particle (TP) on a comb lattice populated by randomly moving hardcore particles. When the TP is constrained to move on the backbone of the comb and in the limit of high density of the particles, we present exact analytical results for the cumulants of the TP position, showing a subdiffusive behavior $t^{3/4}$. At longer times, a second regime is observed where standard diffusion is recovered, with a surprising nonanalytical dependence of the diffusion coefficient on the particle density. When the TP is allowed to visit the teeth of the comb, we unveil a rich and complex scenario with several successive subdiffusive regimes, resulting from the coupling between the geometrical constraints of the lattice and particle interactions. In this case, remarkably, the presence of hard-core interactions asymptotically speeds up the TP motion along the backbone of the structure.

DY 22.2 Tue 14:15 H47

Anomalous transport of circular swimmers in disordered structures: classical edge-state percolation — •Thomas Franosch[1], Walter Schirmacher[2], Benedikt Fuchs[3], and Felix Höfling[4] — [1]UIBK Innsbruck — [2]Universität Mainz — [3]Med.-Uni Wien — [4]FU Berlin

Recently micron-sized self-propelled particles have been realized as model systems [1] for complex living organisms such as bacteria. If the agent is asymmetric a natural circular motion [2] emerges which yields characteristic skipping orbits when interacting with boundaries.

Here, we investigate by molecular dynamics simulations the dynamics of circular swimmers in a two-dimensional model with randomly distributed scatterers. For small radii of the swimming motion the agents orbit only around isolated clusters of scatterers, while at large radii diffusive behavior emerges. A de-localization transition occurs which is generated by percolating skipping orbits along the edges of obstacle clusters. Directly at the transition the mean-square displacements displays subdiffusive transport. The dynamic exponents differ from those of the conventional transport problem on percolating systems, thus establishing a new dynamic universality class [3]. Last, we draw an analogy to the field-induced localization transition in magnetotransport in 2D electron gases in a disordered array of antidots.

[1] F. Kümmel, et al., Phys. Rev. Lett. **110**, 198302 (2013).

[2] S. van Teeffelen and H. Löwen, Phys. Rev. E **78**, 020101(R) (2008).

[3] W. Schirmacher, B. Fuchs, F. Höfling, and T. Franosch, Phys. Rev. Lett. (2015, in print).

DY 22.3 Tue 14:30 H47

Scales of Function Spaces for Weyl Fractional Calculus — •Tillmann Kleiner and Rudolf Hilfer — Institute for Computational Physics, University of Stuttgart, Germany

Anomalous diffusion models are frequently based on fractional differential equations [1]. Analytical investigations of these mathematical models require suitable function spaces on which the fractional derivatives operate as continuous operators. This contribution introduces function spaces suitable for Weyl fractional calculus. Scales of locally convex spaces with topology generating seminorms are constructed using weighted maximal functions. These scales are sets of spaces partially ordered by inclusion. Minimal and maximal spaces with respect to this ordering are determined such that Weyl fractional derivatives operate on them continuously or isomorphically. Such spaces can also be determined for sets of linear combinations of these operators with orders restricted to some fixed subset of $\mathbb{C}$. Inclusions of spaces within the scale correspond to continuous injections with dense range. As a result the investigated operators and their inverses are continuous extensions from the subspace of test functions for all suitable spaces.

[1] *Applications of Fractional Calculus in Physics*, edited by R. Hilfer (World Scientific, Singapore, 2000).

DY 22.4 Tue 14:45 H47

A simple non-chaotic map generating subdiffusive, diffusive, and superdiffusive dynamics — Lucia Salari[1], Lamberto Rondoni[1,2], Claudio Giberti[3], and •Rainer Klages[4,5] — [1]Dipartimento di Scienze Matematiche, Politecnico di Torino — [2]GraphenePoliTO Lab, Politecnico di Torino and INFN Sezione di Torino — [3]Dipartimento di Scienze e Metodi dell' Ingegneria, Universita di Modena e Reggio E. — [4]Max Planck Institute for the Physics of Complex Systems, Dresden — [5]School of Mathematical Sciences, Queen Mary University of London

Consider equations of motion that generate dispersion of an ensemble of particles in the long time limit. An interesting problem is to predict the diffusive properties of such a dynamical system starting from first principles. Motivated by numerical results on diffusion in polygonal billiards, we introduce an interval exchange transformation lifted onto the whole real line that mimicks deterministic diffusion in these billiards. By definition our simple map model is not chaotic, in the sense of exhibiting a vanishing Lyapunov exponent. We show analytically that it nevertheless displays a whole range of normal and anomalous diffusion under variation of a single control parameter [1].

[1] L. Salari et al., Chaos **25**, 073113 (2015)

DY 22.5 Tue 15:00 H47

Localisation of ballistic tracers in the two-dimensional Lorentz model interpreted as a renormalisation group flow — •Felix Höfling — Fachbereich Mathematik und Informatik, Freie Universität Berlin — Max-Planck-Institut für Intelligente Systeme, Stuttgart, und IV. Institut für Theoretische Physik, Universität Stuttgart

The Lorentz model serves as a minimal model to explain many facets of the rich phenomenology of anomalous transport, as frequently observed in porous materials and cellular transport [1]. Here, I will discuss the localisation transition of “ballistic” tracers (subject to Newton's equations of motion) in the two-dimensional, overlapping Lorentz model. Extensive simulations provide evidence for the universality of the dynamic critical exponent, which has been crucial in the interpretation of recent studies [2,3]. The long-time asymptotes, however, are obscured by non-universal corrections to scaling, explaining the contradicting values for the diffusivity exponent in the literature. A spectral analysis of the obtained correlation functions allows for an interpretation of the dynamics as an renormalisation flow of the transport at long times and gives insight into the fixed point structure of the RG flow.

[1] F. Höfling and T. Franosch, Rep. Prog. Phys. **76**, 046602 (2013).

[2] S. K. Schnyder, M. Spanner, F. Höfling, T. Franosch, and J. Horbach, Soft Matter **11**, 701 (2015).

[3] W. Schirmacher, B. Fuchs, F. Höfling, and T. Franosch, arXiv:1511.05218, Phys. Rev. Lett. in print (2015).

DY 22.6 Tue 15:15 H47

Non-adiabatic quantum pumping by a randomly moving quantum dot [1] — •Daniel Waltner[1] and Stanislav Derevyanko[2] — [1]Faculty of Physics, University of Duisburg-Essen, 47048 Duisburg, Germany — [2]Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot 76100, Israel

We look at time dependent fluctuations of the electrical charge in an open 1D quantum system represented by a quantum dot experiencing random lateral motion. In essentially non-adiabatic settings we study both diffusive and ballistic (Levy) regimes of the barrier motion where the electric current as well as the net pumped electric charge experience random fluctuations over the static background. We show that in the large-time limit, the wavefunction is naturally separated into the Berry-phase (BP) component (resulting from the singular part of the wave amplitude in the co-moving frame) and the non-adiabatic correction (arising from fast oscillating, slow decaying tails of the same amplitude). Based on this separation we report two key results: firstly, the disorder averaged wave function and current are asymptotically mainly determined by the same BP contribution that applies in the case of adiabatic motion. Secondly, after a short transition period the pumped electric charge exhibits fluctuations that grow much faster than predicted by the adiabatic theory. We also derive the exact expressions for the average propagator (in the co-moving basis representation) for the diffusive and ballistic types of motion considered.

[1] S. Derevyanko, D. Waltner, J. Phys. A **48** (2015) 305302