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The Open-Access Journal for the Basic Principles of Diffusion Theory, Experiment and Application

Complex transport in strongly disordered materials

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The Lorentz model constitutes a reference model for transport in disordered materials. Here a tracer meanders through an array of frozen obstacles which in the simplest variant are assumed to be distributed independently. As the density of scatterers increases, the regions of excluded volume start to overlap until eventually long-range transport ceases to exist entirely. This localization transition is of purely geometric origin and coincides with the percolation of the void space.

In the talk I present our recent results on the dynamics close to the transition threshold and show that the simulation results nicely corroborate scaling behavior. The motion is first characterized in terms of the mean-square displacement both for the all-cluster-averaged dynamics [1], as well as for particles confined to the percolating cluster [2]. The critical exponents associated with the respective dynamics are shown to be connected by simple exponent relations. Equivalently to the mean-square displacements, the time-dependent diffusion coefficient or the velocity autocorrelation function encodes the slowing down of the dynamics as the critical obstacle density is approached. In the frequency domain, the quantity of interest are the dynamic conductivity or the frequency-dependent polarizability. Here the critical dynamics is reflected by a power-law decrease of the conductivity directly at the transition point. Beyond the second moment I briefly discuss the non-gaussian parameter and discuss the corresponding critical behavior.

Second, I show that for Brownian tracers the dynamics of the Lorentz model can be derived analytically in the limit of low obstacle densities [3]. Already at this order the velocity autocorrelation function displays an algebraic tail, indicative of persistent correlations due to repeated encounters with the same obstacle. Our result support the idea that quenched disorder provides a generic mechanism for persistent correlations irrespective of the microdynamics of the tracer particle. Our analytic approach is corroborated by computer simulations with a surprisingly large range of validity for the two-dimensional case.

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[2] M. Spanner, F. Höfling, G.E Schröder-Turk, K. Mecke and T. Franosch, Anomalous transport of a tracer on percolating clusters, J. Phys. Condens. Mat. **22,** xxx (2011)

[3] T. Franosch, F. Höfling, T. Bauer, and E. Frey, Persistent memory for a Brownian walker in a random array of obstacles, Chem. Phys. **375,** 540 (2010).