“Anomalous transport in heterogeneous environments and crowded cells”

Anomalous, slow transport is widely observed for tracer particles in heterogeneous host matrices; such structures can emerge from (quasi-)arrested liquids and are typically found in hierarchical porous materials, ion-conducting glass formers, and approximately in densely crowded cellular fluids. Diffusion is strongly suppressed upon increasing either the size of the tracer or the excluded volume, which can result in a localisation transition. The paradigm for classical localisation in such host structures is provided by the Lorentz model, where a point tracer explores the void space between randomly placed, possibly overlapping hard spheres. Here, the localisation transition is due to an underlying percolation phenomenon, giving rise to a divergent correlation length of the host structure and entailing critical slowing down of the tracer dynamics, visible as subdiffusion at criticality.

Guided by large-scale simulations for the Lorentz model, we have developed an elaborate scaling description of the anomalous transport. I will make connections to random resistor networks and to the “ant in the labyrinth”, and also consider correlated obstacle matrices and tracers that perform Brownian motion. Eventually, I will apply the obtained insight to biological cells, where, for example, proteins diffuse in a highly heterogeneous landscape. I will demonstrate how the anomalous transport due to macromolecular crowding can be measured on a spatio-temporal level by variable-lengthscale fluorescence correlation spectroscopy.