SYAT 2: Anomalous Transport in Heterogeneous Media II

Time: Wednesday 16:30–18:00 Location: H1

Invited Talk SYAT 2.1 Wed 16:30 H1

The Lorentz model: a paradigm of anomalous transport — •Felix Höfling — Rudolf Peierls Centre f. Theoretical Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, United Kingdom

Transport in spatially heterogeneous materials such as rocks, soils, gels, and ceramics is strongly hindered and often anomalously slow. Subdiffusive motion is found further in cell membranes and in the cytoplasm, which are densely packed with differently sized proteins, lipids, and sugars, summarised as macromolecular crowding.

The Lorentz model provides a simplistic model for transport in a spatially heterogeneous medium, the latter being represented by randomly distributed obstacles. Slow dynamics and anomalous transport emerge generically over the full range of packing fractions. A localisation transition induces subdiffusive motion, which is observed over many decades in time close to the critical point. The dynamics is rationalised in terms of a cluster-resolved scaling theory and characterised by a set of universal exponents.

A two-dimensional version of the Lorentz model is motivated by the subdiffusive motion of membrane proteins, which can be measured with fluorescence correlation spectroscopy (FCS). Based on FCS experiments *in silico*, it is shown that varying the beam waist of the illuminating laser reveals the intricate interplay of the heterogeneous medium and the anomalous transport. Going beyond the common assumption of spatially Gaussian transport, the analogy of FCS to other dynamic scattering methods is highlighted, establishing its potential of resolving complex dynamics in both space and time.

Invited Talk SYAT 2.2 Wed 17:00 H1

Viscoelastic subdiffusion: from anomalous to normal — •Igor Goychuk — Institut für Physik, Universität Augsburg, Germany

The subdiffusional search can bring certain advantages for the cell functioning. However, it can also entail fatal consequences by leading to vanishing effective rates of the subdiffusion-limited binding reactions. Yet there is an increasing body of evidence for the occurrence of subdiffusion in healthy biological cells. Which is the physical mechanism for it and why it can be beneficial? Different answers are currently given. I will discuss one physical mechanism based on the viscoelasticity of complex crowded media within a generalized Langevin equation description. It will be shown that: (i) this mechanism is ergodic, (ii) it does not entail a quasi-infinite mean residence time in a finite spatial domain, and therefore (iii) the subdiffusion-limited binding rate is finite. The escape kinetics out of a potential well follows asymptotically a stretched-exponential law. However, in the limit of high barriers it becomes ever more normal and described by the non-Markovian rate theory. This limit of exponential kinetics can be practically achievable or not, depending on the subdiffusion exponent, memory cutoff, potential height and temperature. Surprisingly, in periodic potentials such a viscoelastic subdiffusion is asymptotically not sensitive to the presence of potential. However, the transient regime with a slowly changing subdiffusion exponent can last very long and initially resemble normal diffusion. Such a combination of anomalous and normal features selects viscoelastic mechanism as biologically most relevant [1].

[1] I. Goychuk, Phys. Rev. E **80**, 046125 (2009).

Invited Talk SYAT 2.3 Wed 17:30 H1

Phase transitions, liquid micro-compartments, and embryonic patterning — •Clifford Brangwynne[1,2], Jöbin Gharakhani[1], Anthony Hyman[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute for Molecular Cell Biology and Genetics, Dresden, Germany

Cells contain many RNA/protein micro-compartments that are not bound by membranes, such as germ granules, Cajal bodies, and nucleoli. How these structures assemble and disassemble, and what maintains their shape and structural integrity, are poorly understood. Here we focus on germ granules (P granules) in C.elegans embryos. In the 1-cell embryo, P granules are partitioned into one of the two daughter cells by an unknown mechanism. Using fluorescence imaging and 3D particle tracking, we find that P granule partitioning occurs by a biased increase in their condensation at the posterior end of the embryo. P granules were found to have a surprisingly liquid-like character, exhibiting behaviors such as fusion, dripping and wetting; their partitioning appears to represent a kind of liquid-liquid phase transition, in which polarity proteins establish a gradient in the condensation point across the cell. This gradient itself results from a spatially varying diffusivity of key polarity proteins. P granule partitioning thus reflects an intracellular phase transition spatially regulated by a patterning reaction-diffusion process.