BP 17: Anomalous Transport I (joint BP, DY)

Time: Wednesday 9:30–11:00 Location: H38

BP 17.1 Wed 9:30 H38

Elucidating the origin of anomalous diffusion in crowded fluids — Jedrzej Szymanski and •Matthias Weiss — Cellular Biophysics Group, German Cancer Research Center, Heidelberg

Anomalous diffusion in crowded fluids, e.g. in the cytoplasm of living cells, is a frequent phenomenon. So far, however, the associated stochastic process, i.e. the propagator of the random walk, has not been uncovered. Here, we show by means of fluorescence correlation spectroscopy and simulations that the properties of crowding-induced subdiffusion are consistent with the predictions for fractional Brownian motion or obstructed (percolation-like) diffusion, both of which have stationary increments. In contrast, our experimental results cannot be explained by a continuous time random walk with its distinct non-Gaussian propagator.

Reference J. Szymanski & M. Weiss, Phys. Rev. Lett. 103, 038102 (2009).

BP 17.2 Wed 9:45 H38

Macromolecular crowding - probing the microscopic protein diffusion on nanosecond time scales — •Felix Roosen-Runge[1], Marcus Hennig[1,2], Fajun Zhang[1], Tilo Seydel[2], and Frank Schreiber[1] — [1]Institut für Angewandte Physik, Universität Tübingen, Germany — [2]Institut Laue-Langevin, Grenoble, France

In the cellular interior, macromolecules occupy high volume fractions. This so-called macromolecular crowding affects both cellular structure and function, as reported from both simulations and kinetic measurements. From a dynamical point of view, however, protein diffusion in crowded media is far from understood. The nature of diffusion is expected to show different regimes of simple and anomalous diffusion, depending on the respective time and length scale.

Using quasi-elastic neutron scattering (QENS) at time scales of nanoseconds and length scales of several nanometers, we probe the self diffusion in crowded solutions of bovine serum albumin (BSA). The temperature dependence of the effective diffusion coefficient below thermal denaturation can be rationalised based on the Stokes Einstein relationship; addition of NaCl cause little or no changes. The concentration dependence is the most pronounced effect: the apparent diffusion coefficient, covering volume fractions ranging from 5% up to 40%, strongly decreases with increasing protein concentration. A careful deconvolution of rotational and translational contributions provides insights in the simple diffusive nature of protein motions probed by neutron backscattering. The findings are also discussed in comparison to results from colloid physics.

BP 17.3 Wed 10:00 H38

Electrostatic interactions modulate particle translocation in reconstituted mucus hydrogels — •Oliver Lieleg, Ioana Vladescu, and Katharina Ribbeck — FAS Center for Systems Biology, Harvard University, Cambridge, USA

Biological functional entities surround themselves with selective barriers which control the passage of certain classes of macromolecules while rejecting others. A prominent example of such a selective permeability barrier is given by mucus. Mucus is a biopolymer based hydrogel which lines all wet epithelial surfaces of the human body. It regulates the uptake of nutrients from our gastrointestinal system, adjusts itself with the menstrual cycle to control the passage of sperm, and shields the underlying cells from pathogens such as bacteria and viruses. In the case of drug delivery, the mucus barrier needs to be overcome for successful medical treatment. Despite its importance for both physiology and medical applications, the underlying principles which regulate the permeability of mucus remain enigmatic. Here, we analyze the mobility of microscopic particles in reconstituted mucin hydrogels. We show that electrostatic interactions between diffusing particles and mucin polymers regulate the permeability properties of reconstituted mucin hydrogels. As a consequence, various parameters such as particle surface charge, mucin density, and buffer conditions such as pH and ionic strength can modulate the microscopic barrier function of the mucin hydrogel. Our findings suggest that the permeability of a single biopolymer based hydrogel such as native mucus can be tuned to a wide range of settings in different compartments of our bodies.

BP 17.4 Wed 10:15 H38

Subdiffusive Dynamics in Dense Driven Granular Media — •Matthias Sperl and Elmar Staerk — DLR Cologne

Granular media is characterized by non-elastic collisions among particles and obstacles; collisions lead to dissipation of energy. This lost energy needs to be replenished to achieve a steady state, and such a non-equilibrium steady state is investigated in our experiments. The driving is realized in two dimensions on a vibrating table; the particles dynamics is monitored by high-speed cameras with a specially adapted long-time recording system: Several minutes of dynamics can be recorded with millisecond resolution. The dynamical window allows the identification of several decades of anomalous dynamics and respective exponents in the mean-squared displacement. We investigate two granular systems in their dense regime: (1) a granular Lorentz system, where a single particles explores an environment of quenched disorder, and (2) the glass-like dynamics of a system with many particles. In both cases, the resulting dynamics shows both remnants of their equilibrium counterparts and marked differences. E.g., results vary with differences in the rates of driving and dissipation. A comparison with results from theory and computer simulation will be performed.

BP 17.5 Wed 10:30 H38

Localization and glass formation of colloids confined in porous media — •Jan Kurzidim, Daniele Coslovich, and Gerhard Kahl — Institut für Theoretische Physik and Center for Computational Materials Science, Technische Universität Wien, Wiedner Hauptstraße 8-10, A-1040 Wien, Austria

Using molecular dynamics simulations we study the slow dynamics of a hard-sphere fluid confined in a matrix quenched from an equilibrated hard-sphere fluid [Kurzidim *et al.*, PRL **103**, 138303 (2009)], resembling the movement of hard colloids in porous environments. We observed the presence of both discontinuous and continuous glass transitions, anomalous diffusion, and a de-coupling of the time scales for the relaxation of the single-particle and the collective correlators. Our observations are consistent with many predictions of a recent extension of mode-coupling theory for so-called "quenched-annealed" systems. Notably, however, we found no evidence of the re-entrant regime in the kinetic diagram predicted by the theory. To provide a deeper insight into the microscopic details of the underlying processes, we calculated the quantities of interest separately for particles trapped in voids formed by the matrix and for particles that unrestrictedly move through the entire system. In order to evaluate the degree of universality of the observed phenomena, we extended our investigation to model colloids with soft interactions, employing both numerical solutions of the equations of the theory, and molecular dynamics simulations.

BP 17.6 Wed 10:45 H38

Anomalous transport in a medium subjected to phase transition — Daria Kondrashova, Jörg Kärger, and •Rustem Valiullin — Deprtment of Interface Physics, University of Leipzig, Leipzig, Germany

Diffusion in spatial structures created via invasion percolation may naturally exhibit anomalous properties. It is now becoming evident that phase transitions occurring in heterogeneous media, may also be described using the concept of invasion percolation [1]. Hence, transport properties of tracer particles in media subjected to phase changes can strongly be affected by the latter process, including conditions giving rise to anomalous transport patterns. In this work, we experimentally demonstrate that such fractal-like structures are developing during freezing and melting transitions of liquids in disordered mesoporous matrices. We show that the effective self-diffusivity in the pore space, occupied by the liquid phase at a given fraction, depends on a particular configuration of the frozen phase [2]. Interestingly, by using a porous material with tubular pore morphology, we were able to relate the phase transition kinetics to the propagation of the liquid-solid interfaces in the pores. Depending on temperature, this propagation itself is found to exhibit a spectrum of behavior from diffusive to anomalous. The data obtained may have implications for understanding anomalous transport in bio-systems such as lipid membranes.

1. Page, J. H., J. Liu, B. Abeles, H. W. Deckman and D. A. Weitz, Phys. Rev. Lett., 71, 1216 (1993). 2. Dvoyashkin, M., A. Khokhlov, R. Valiullin and J. Kärger, J. Chem. Phys., 129, 154702 (2008).