DY 35: Brownian Motion and Transport

Time: Friday 9:30–11:30 Location: H48

DY 35.1 Fri 9:30 H48

Two-dimensional transport of paramagnetic colloids via an AC-induced ratchet — •Robert Gernert and Sabine H. L. Klapp — Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

Magnetic garnet films are characterized by a striped magnetisation which can be adjusted through an external homogeneous magnetic field. An oscillating field drives paramagnetic colloids, which perform Brownian motion in a plane above the film, out of equilibrium and induces a ratchet effect.[1 2] We investigate the dependence of the arising transport on particle interaction. The Gaussian core model is used to define the interaction potential.

The Brownian motion is assumed to be overdamped. As a framework for solving the equation of motion for the time-dependent probability density, we employ the Dynamical Density Functional Theory (DDFT) where the microscopic particle interactions enter via a free energy functional.[3]

Mean squared displacement, diffusion coefficient and other transport properties are calculated in two dimensions and in a one-dimensional cut perpendicular to the stripes of magnetisation. First results of simulations including attractive magnetic dipole interactions are shown.

[1] P. Tierno, F. Sagues, T. H. Johansen and T. M. Fischer, Phys. Chem. Chem. Phys. **11**, 9615 (2009)

[2] A. Fortini and M. Schmidt, Phys. Rev. E **83**, 041411 (2011)

[3] A. J. Archer and R. Evans, J. Chem. Phys. **121**, 4246 (2004)

DY 35.2 Fri 9:45 H48

Computersimulation of colloidal particles in two-dimensional channel geometries. — •Ullrich Siems and Peter Nielaba — University of Konstanz, Germany

This talk will present the results of Brownian Dynamics Simulations of colloidal particles in external fields confined in two-dimensional channels. Superparamagnetic Brownian particles are well suited 2d model-systems for a variety of problems on different length scales, ranging from pedestrian walking through a bottleneck to ions passing ion-channels in living cells. In such systems confinement into channels can have a great influence on the diffusion and transport properties. In our study interacting colloidal particles were dragged over a washboard potential and are additionally confined in a two-dimensional micro-channel.

DY 35.3 Fri 10:00 H48

Brownian Transport in corrugated narrow channels - inertia effects — •Gerhard Schmid and Peter Hänggi — Universität Augsburg

The transport of Brownian particles through corrugated narrow channels is investigated [1,2]. Interestingly, inertial contributions to the particle dynamics cannot be neglected a priori. Especially, for widths of the channel's bottlenecks smaller than an appropriate particle diffusion length determined by the channel's geometrical parameters and the strength of the forcing, the Smoluchowski approximation breaks down and inertial effects come into play. The inertia corrections to the transport quantifiers, mobility, and diffusivity markedly differ for smoothly and sharply corrugated channels [2].

[1] P.S. Burada, P. Hänggi, F. Marchesoni, G. Schmid, and P. Talkner, ChemPhysChem **10**, 45 (2009).

[2] P.K. Ghosh, P. Hänggi, F. Marchesoni, F. Nori, and G. Schmid, Phys. Rev. E **86**, 021112 (2012).

DY 35.4 Fri 10:15 H48

Determination of eigenvalues of the diffusion tensor in anisotropic systems with orientation change in time and space — •Mario Heidernätsch and Günter Radons — Chemnitz University of Technology, D-09126 Chemnitz, Germany

Anisotropic diffusion is one possible generalization of homogeneous diffusion processes. It occurs typically in systems with anisotropic media such as liquid crystals or in isotropic media when the diffusing particle or molecule has an ellipsoidal shape. It can be formally described by an extended Fokker-Planck-equation using a diffusion tensor. We show how the moments of the distribution of diffusivities [1] can be used in a simple fashion to obtain the eigenvalues of the diffusion tensor from trajectories of such anisotropic processes. For the example of a three-dimensional anisotropic systems with twist, we show how the method regains the principal diffusion coefficients. In such systems, which are mathematical equivalent to two-dimensional diffusion of an ellipsoid in isotropic media, other methods are harder to accomplish and need better data [2], or might even fail.

[1] M. Bauer et al., J. Chem. Phys. 135, 144118 (2011)

[2] C. Ribrault et al., Phys. Rev. E 75, 021112 (2007)

DY 35.5 Fri 10:30 H48

Fluctuations and equipartition in the dynamics of granular ratchets — •Johannes Blaschke and Jürgen Vollmer — Max Planck Institute for Dynamics and Self-Organization, Göttingen

Collisions involving granular particles exhibit dissipative kinematics. Hence, the motion of granular particles cannot be described using thermodynamics alone, warranting an examination of theories of non-equilibrium steady states and fluctuation theorems.

We examine the motion of a macroscopic wedge-shaped particle (constrained to only move along the x-axis) encountering dissipative collisions with granular gas particles. Based on a general stochastic model, we derive the full PDF of the wedge's motion. Contrary to what is observed for a Maxwell-Boltzmann gas, vanishingly small perturbations to the gas velocity PDF (e.g. via shaking) result in a steady-state drift velocity independent of wedge mass in the limit of a massive particle.

DY 35.6 Fri 10:45 H48

Collective particle dynamics crossing the freezing transition — •Markus Franke[1], Sebastian Golde[1,2], and Hans Joachim Schöpe[1,3] — [1]Johannes Gutenberg-Universität, Institut für Physik, Staudingerweg 7, 55128 Mainz, Germany — [2]Graduate School Material Science in Mainz, Staudinger Weg 9, 55128 Mainz, Germany — [3]Max-Planck-Institut für Polymerforschung, Postfach 3148, 55021 Mainz, Germany

We studied the collective particle dynamics in a hard sphere colloidal modell system of highly cross-linked polystyrene (PS) microgel particles dispersed in the good solvent 2-ethylnaphthalene. We determined the dynamics of the colloidal fluid around the main structure factor peak ($1.7<qR<5$) over a wide concentration range crossing the freezing transition point using dynamic light scattering. This gives access to the intermediate scattering function (ISF) which measures particle number density fluctuations or collecitve particle dynamics respectively. Further analyzation of the ISF dynamics shows that there is a significant difference in the relaxation mechanism of the collective density fluctuations of a fluid in the stable state and in the metastable state. In the nonequilibrium state the dynamics becomes heterogeneous in space and time. Once crossing the freezing point the fluid seperates in two fractions: One shows the dynamic signature of an equilibrium fluid and one displays an unequlibrium collective mode.

DY 35.7 Fri 11:00 H48

Mass loading induced dephasing in nanomechanical resonators — •Juan Atalaya — Institut für Theoretische Festkörperphysik, Karlsruher Institut für Technologie, Karlsruher, Deutschland.

I study dephasing of an underdamped nanomechanical resonator subject to random mass loading of small particles. I propose a frequency noise model to describe dephasing due to attachment and detachment of particles at random points and particle diffusion along the resonator. This situation is commonly encountered in current mass measurement experiments using nanoelectromechanical (NEM) resonators. I discuss the conditions which can lead to inhomogeneous broadening and fine structure in the vibrational modes absorption spectra. I show that the spectra of the higher-order cumulants of the (complex) vibrational mode amplitude are sensitive to the parameters characterizing the frequency noise process. Hence, measurement of these cumulants can provide information not only about the mass but also about other parameters of the adsorbed particles (diffusion coefficient, attachment and detachment rates).

DY 35.8 Fri 11:15 H48

Brownian motion of a heated colloid — •Dipanjan Chakraborty[1,2], Manuel Gnann[3], Daniel Rings[4], Felix Otto[3], Frank Cichos[5], and Klaus Kroy[4] — [1]MPI-IS,Stuttgart, Germany

— [2]IVth Physics Institute, University of Stuttgart, Germany — [3]MPI for Mathematics in Sciences, Leipzig, Germany — [4]ITP, University of Leipzig, Germany — [5]EXP-I, University of Leipzig, Germany

We establish a generalized Stokes-Einstein relation and an effective Markovian theory for hot Brownian motion [1-3]. Hot Brownian motion is the stochastic thermal motion of a nanoparticle maintained at an elevated temperature with respect to the ambient fluid, a scenario which is often encountered when a light-absorbing tracer particle diffuses in the focus of a laser. The temperature profile around the nanoparticle can be detected by a second laser, which can be exploited in photothermal particle tracking and spectroscopy techniques [4]. Our effective Markovian description serves as a valuable quantitative descritption for a wide variety applications using hot nanoparticles.

[1] D. Chakraborty, M. V. Gnann, D. Rings, J. Glaser, F. Otto, F. Cichos and K. Kroy, Europhys. Lett. 96(6), 60009 (2012).
[2] D. Rings, D. Chakraborty and K. Kroy, New Journal of Physics, 14(5), 53012 (2012).
[3] D. Rings, R. Schachoff, M. Selmke, F. Cichos, and K. Kroy, Phys. Rev. Lett., 105 (9), 090604 (2010)
[4] R. Radünz, D. Rings, K. Kroy, and F. Cichos, J. Phys. Chem. A 113 (9), 1674-1677 (2009)