CPP 25: Diffusion and Dynamics

Time: Wednesday 15:30–17:15 Location: ZEU 160

CPP 25.1 Wed 15:30 ZEU 160

Hot Brownian Motion — •Daniel Rings[1], Romy Radünz[2], Frank Cichos[2], and Klaus Kroy[1] — [1]ITP, Uni Leipzig, Germany — [2]EXP1, Uni Leipzig, Germany

Brownian motion is abundant throughout the microscopic and mesoscopic world. Since Einstein's seminal work, there is a good understanding of this process under conditions of thermal equilibrium. Brownian motion of particles in media with inhomogeneous temperature distributions poses several new questions. One way – already introduced by Maxwell – to cope with temperature gradients is to modify the boundary conditions at the particle's surface and allow slip in order to account for effects of thermal gradients. This approach is purely phenomenological, however, and does not take into account the temperature-dependence of the solvent viscosity, which is pronounced in water and e. g. hence most relevant for biological systems.

Here, we present a simple theoretical model for a suspension of heated Brownian particles. We determine the Stokes' flow around a spherical particle for radially varying viscosity and thus obtain effective quantities $\tilde{\eta}, \tilde{T}$. With these, we formulate a generalized Stokes-Einstein relation $6\pi\tilde{\eta}RD = k_B\tilde{T}$, which has been justified by a novel experimental technique called Photothermal Correlation Spectroscopy (PhoCS) presented by Romy Radünz also at this conference.

CPP 25.2 Wed 15:45 ZEU 160

Application of photothermal correlation spectroscopy to the study of hot Brownian motion — •Romy Radünz[1], Daniel Rings[2], Klaus Kroy[2], and Frank Cichos[1] — [1]Molecular Nanophotonics Group, Institute of Experimental Physics I, University Leipzig, Linnéstraße 5, 04103 Leipzig — [2]Soft Condensed Matter Theory, Institute of Theoretical Physics, University Leipzig, Vor dem Hospitaltore 1, 04103 Leipzig

We introduce a new technique for the measurement of tracer dynamics, which is sensitive to single metal nanoparticles down to a radius of 2.5 nm with a time resolution of a few microseconds. The method is based on a fluctuation analysis of a heterodyne photothermal scattering signal, which is recorded in a simple confocal microscopy setup. It exploits the same principles as fluorescence correlation spectroscopy but targets the use of extremely photostable, non-fluorescent, nanosized tracers as a replacement of fluorescent probes. To validate our approach, we verify that the Stokes-Einstein relation holds for heated diffusing gold nanoparticles, with an effective viscosity and temperature predicted by a semi-quantitative analytical model. We further demonstrate first applications to gold nano-particle diffusion in biomaterials. Due to the photostability and the low size dispersion of gold nanoparticles, the method promises broad applications especially in the field of high throughput biological screening.

CPP 25.3 Wed 16:00 ZEU 160

Dynamic Density-Functional Theory in Flow and Nonuniform Temperature — •Markus Hütter[1] and Joseph M. Brader[2] — [1]ETH Zürich, Department of Materials, Polymer Physics, CH-8093 Zürich, Switzerland — [2]Universität Konstanz, Fachbereich Physik, D-78457 Konstanz, Germany

Dynamic density functional theory has proven to be a useful tool for studying the dynamics of colloidal suspensions. Recent attempts have aimed to incorporate flow, non-uniform temperature gradients and hydrodynamic interactions. In this contribution, we take the first steps towards constructing a unified, thermodynamically consistent theory for the complete colloid plus solvent system. First, in order to examine the effect of strongly non-local effects, we formulate a thermodynamically admissible set of evolution equations for a one-component fluid in terms of the densities of mass, momentum, and internal energy. By using coarse-graining techniques, one can examine how long-range interactions on the particle level affect the macroscopic continuum description. The following conclusions emerge. (i) The body forces in the momentum balance have both energetic and entropic contributions in general, but can not be summarized in terms of a free energy-related term. (ii) The thermal conductivity and the viscosity are non-local in space. Second, we consider the colloid plus solvent system. Specifically, we present the evolution equations for the nonisothermal hydrodynamics of the solvent and for the spatial distribution of the colloids. In this way, it is clarified how the latter evolution equation can be extended to flow and nonisothermal situations.

CPP 25.4 Wed 16:15 ZEU 160

Cluster-resolved scaling theory for particle transport on percolating systems — Axel Kammerer, •Felix Höfling, and Thomas Franosch — Arnold Sommerfeld Center for Theoretical Physics (ASC) and Center for NanoScience (CeNS), Fakultät für Physik, Ludwig-Maximilians-Universität München, Germany

A Brownian particle moving between randomly distributed obstacles, a variant of the Lorentz model, constitutes a simple model for transport in heterogeneous environments. Three major transport phenomena are observed: normal diffusion, localization, and anomalous transport. All three aspects may be unified into the concept of transport in a medium with a percolation transition. Recent simulations have revealed that the asymptotic subdiffusive behaviour is only slowly approached and the large corrections cannot be ignored [1].

Thus, it is of general interest to develop a systematic description of universal corrections to scaling in percolating systems [2]. We have derived a new universal exponent relation connecting the leading corrections to scaling of the static cluster structure and of the transport dynamics. The derivation relies on a cluster-resolved scaling theory, unifying the scaling of both the cluster size distribution and the dynamics of a random walker. We have corroborated our scaling theory as well as the exponent relation in detail by large-scale simulations for the square lattice.

[1] Höfling, Franosch, and Frey, Phys. Rev. Lett. **96,** 165901 (2006).

[2] Kammerer, Höfling, and Franosch, arXiv:0811.1414, to appear in Europhys. Lett. (2008).

CPP 25.5 Wed 16:30 ZEU 160

Diffusion of magnetic nickel nanorods in colloidal dispersions — •Annegret Günther, Andreas Michels, Andreas Tschöpe, and Rainer Birringer — Technische Physik, Universität des Saarlandes, Postfach 151150, Geb. D2 2, D-66041 Saarbrücken, Germany

Ni nanorods with varying aspect ratios were synthesized by electrodeposition of Ni into porous alumina templates. The nanorods were extracted from the matrix by dissolution of the alumina and were dispersed in water or water-glycerine mixtures. The dynamics of the rods in colloidal dispersions in terms of the rotational and translational diffusion was investigated. Rotational diffusion of the nanorods was characterized by AC susceptibility measurements from 10 to 10000 Hz and by optical transmission measurements. The translational diffusion was studied by single particle tracking (SPT) of trajectories which were observed by laser scattering in an optical microscope. The rotational and translational diffusion coefficients were analyzed with regard to the aspect ratio of the Ni nanorods.

CPP 25.6 Wed 16:45 ZEU 160

Diffusional and orientational dynamics of various single terrylene diimide conjugates in mesoporous materials — •Florian Feil, Christophe Jung, Johanna Kirstein, Jens Michaelis, and Christoph Bräuchle — Department of Chemistry und Biochemistry, Ludwig-Maximilians-Universität München, Butenandtstrasse 11, 81377 München (Germany)

Mesoporous silica materials are ideally suited as host-guest systems in nanoscience with applications ranging from molecular sieves, catalysts, nanosensors to drug delivery systems. For all these applications a thorough understanding of the interactions between the mesoporous host system and the guest molecules is vital. Here, we use single molecule spectroscopy to study the dynamics of three different terrylene diimide dyes acting as molecular probes in hexagonal and lamellar mesoporous silica films. The diffusion behaviour in the hexagonal phase is represented by the trajectories of the single molecules which are highly structured and thus provide information about the underlying host structure, such as domain size or the presence of defects inside the host structure. In the lamellar phase, the differences between the three guests are quite dramatic. Two populations of diffusing molecules could be observed: one with parallel orientation of the molecules to the lamellae and the other with perpendicular orientation. Additionally, switching between the two populations was observed. These data provide new insights into host-guest interactions like the influence of the molecular structure of the guest molecules on their diffusional as

well as on their orientational behaviour in structurally confined guest systems.

CPP 25.7 Wed 17:00 ZEU 160

Single molecule studies of mesoporous silica structures for drug-delivery applications — •Timo Lebold, Christophe Jung, Thomas Bein, Jens Michaelis, and Christoph Bräuchle — Center for Nanoscience (CeNS) and Nanosystems Initiative Munich (NIM), Ludwig-Maximilians-Universität München, Department of Chemistry and Biochemistry, Butenandtstraße 11, 81377 München

Novel drug-delivery systems based on nanostructures can provide fundamental progress to many therapies in medicine. We apply mesoporous thin silica films with nanometer-sized pores as drug carriers and incorporate the anti-cancer drug Doxorubicin. The measurements conducted on a single-molecule level provide insights into mechanistic details of the diffusion process. The diffusion dynamics of the drug inside the host channel system is controlled and modified. Further, the release kinetics of the drug is determined and live-cell measurements prove the applicability of the system for drug-delivery. This study demonstrates the high potential of nanoscience for medicine.