CPP 43: Colloids and Complex Liquids II

Time: Thursday 14:00–17:45 Location: H39

CPP 43.1 Thu 14:00 H39

Lattice Boltzmann simulations of suspensions with multiple fluid components — •Jens Harting[1,2] and Fabian Jansen[2] — [1]Dept. of Applied Physics, TU Eindhoven, Postbus 513, NL-5600MB Eindhoven — [2]Institute for Computational Physics, University of Stuttgart, Pfaffenwaldring 27, D-70569 Stuttgart

This contribution has been withdrawn.

CPP 43.2 Thu 14:15 H39

A simplified particulate model for coarse-grained hemodynamics simulations — •Florian Janoschek, Jens Harting, and Federico Toschi — Department of Applied Physics, Eindhoven University of Technology, The Netherlands

Simulation of human blood flow is a demanding task both in terms of the complexity of applicable models and the computational effort. One reason is the particulate nature of blood which in first approximation may be treated as a suspension of red blood cells (RBCs) in blood plasma. A second reason is that in realistic geometries typical length scales vary over several orders of magnitude. Usual computational models either cope with this complexity by implementing only a homogenous although maybe non-Newtonian fluid or highly resolve relatively small numbers of RBCs by means of deformable meshes.

Our goal is to develop a coarse-grained and highly efficient yet still particulate model for blood that allows us to simulate up to millions of cells on current parallel supercomputers. We start with a lattice Boltzmann based simulation method for suspensions of rigid particles to account for long-range hydrodynamic interactions. Since real RBCs are not rigid we add anisotropic model potentials to cover the more complex short-range behavior of deformable cells on a phenomenological level. The benefit of the new model lies in the application to multi-scale problems in realistic geometries requiring particulate resolution in some regions and in the opportunity to investigate statistical and time dependent effects in soft particle suspensions like blood. We will present an overview of the model and its rheological properties.

CPP 43.3 Thu 14:30 H39

Changes of dynamical anisotropy characteristics of ferrofluids in a magnetic field — •Jelena Jordanovic and Sabine H. L. Klapp — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Deutschland

We report a Molecular Dynamic study of the dynamical properties of a ferrofluid in equilibrium in the presence of a homogeneous magnetic field. Accordingly, the anisotropic diffusion constant as well as characteristics of the single particle motion are investigated. Experimentally[1] it was observed that diffusion in the directions perpendicular to the field is hindered compared to diffusion in the parallel direction, indicated by a $D_\perp < D_\parallel$ relation between the diffusion constants. However, an opposite relation was found in Brownian Dynamic simulations[2]. We found[3] a connection between both anisotropy characteristics, where the field strength as well as the dipole-dipole coupling strength play a key role. The mechanism behind the field-induced inversion of the diffusion constants' relation is explained from a microscopic point of view by the van Hove correlation function. Moreover, by investigating the single particle motion, we show that the inversion is accompanied by an intermediate deviation from diffusive behavior, which strongly increases with the dipole-dipole coupling strength.

[1] A. Mertelj, L. Cmok, and M. Čopič, Phys. Rev. E **79**, 041402 (2009).
[2] P. Ilg, and M. Kröger, Phys. Rev. E **72**, 031504 (2005).
[3] J. Jordanovic and S. H. L. Klapp, in preparation.

CPP 43.4 Thu 14:45 H39

Monte Carlo simulations of binary two dimensional colloidal crystals confined between planar walls — •Stefan Medina Hernando[1], Peter Virnau[2], and Kurt Binder[3] — [1]Institut für Physik, Uni Mainz, Deutschland — [2]Institut für Physik, Uni Mainz, Deutschland — [3]Institut für Physik, Uni Mainz, Deutschland

Monodisperse two dimensional systems have been studied extensively in theory, computer simulations and experiments. We extend these investigations by simulating asymmetric soft binary colloidal mixtures confined between planar walls. Two cases are presented in detail: In the commensurate case the number of rows in the system is chosen to fit properly between the walls. In the incommensurate case a mismatch is introduced which leads to the occurrence of solitons.

CPP 43.5 Thu 15:00 H39

Monte Carlo simulations of colloid-polymer mixtures in cylindrical confinement — •Alexander Winkler, Peter Virnau, and Kurt Binder — Institut für Physik, Johannes Gutenberg-Universität Mainz

We investigate the Asakura-Oosawa model in cylindrical confinement with Monte Carlo simulations. On the one hand side the system can be regarded as a model for nanopores, on the other hand the system exhibits an interesting "phase behavior" due to its quasi-one-dimensional character. At high polymer reservoir packing fractions, the tube is either filled with liquid or gas. When we approach a "pseudo-critical point" (at reservoir packing fractions above the critical value of the bulk) several interfaces appear and the tube contains both liquid and gas phases, which are studied by extensive Free Energy calculations.

CPP 43.6 Thu 15:15 H39

Density functional theory for a hard disc fluid on graphics cards — •Marlon Ebert — Johannes Gutenberg Universität Mainz

Investigating the rheological properties of two dimensional fluids near the freezing transition provides interesting challenges. In order to approach this problem we use density functional theory (DFT) to determine the static density correlations around one and two test particles. Since DFT calculations in more then one dimension are usually computationally expensive we resort to applying graphics cards as massively parallel computational devices, using the CUDA language. We discuss the signatures of the freezing transition in the static correlations and compare to simulation results. An extension of the static DFT method aimed at the correlation functions under shear will be discussed. From these the rheological properties of the fluid can be deduced.

15 min. break

CPP 43.7 Thu 15:45 H39

Critical Casimir Forces in Binary Colloidal Suspensions — •Olga Zvyagolskaya[1] and Clemens Bechinger[1,2] — [1]2. Physikalisches Institut, Universität Stuttgart — [2]Max-Planck-Institut für Metallforschung, Stuttgart

We investigate the behavior of a dense two-dimensional colloidal system immersed in a critical binary liquid mixture of water and 2,6-lutidine in front of a plane surface. Close to the critical point critical Casimir forces arise whose sign and amplitude strongly depend on the temperature and the preferential adsorption properties of the surfaces. In our experiments we study the behavior of a binary mixture of colloidal particles with opposite preferential adsorption properties. Owing to their different Casimir interaction with the substrate, this leads to different particle motilities. As a function of the temperature, the relative particle concentrations and the preferential adsorption properties of the substrate we find a large variety of metastable structures.

CPP 43.8 Thu 16:00 H39

Airbrush-spray deposition of colloidal polymer film investigated by Grazing Incidence Small Angle X-ray Scattering — •Adeline Buffet, Gerd Herzog, Matthias Schwartzkopf, Mottakin M. Abul Kashem, Jan Perlich, Rainer Gehrke, and Stephan V. Roth — HASYLAB-DESY, Notkestr. 85, D-22607 Hamburg, Germany

Organic-based hybrid devices received strong attention from both academy and industry because of their potential for low-cost production and flexible device applications [1]. Recently, the novel technique of airbrush spray deposition was used in the fabrication of organic-based multilayer devices such solar cells [2]. This technique allows for performing rapid deposition of organic-based nanostructured layers showing high homogeneity over a large area and is thus of great interest in industrial applications. We used Grazing Incidence Small Angle X-ray Scattering (GISAXS) to investigate the structure of a colloidal nanoparticle film deposited on a flat Si-substrate by using a commercial airbrush-spray. The study shows a strong dependence of the film homogeneity on the substrate-to-spray distance and the strong influence of the solvent choice on the film lateral ordering opening a promising route to generate laterally structured templates and scaf-

folds for the fabrication of ultrahigh-density media. [1] G. Kaune et al., Eur. Phys. J. E 26, 73-79 (2008). [2] R. Green, et al., Appl. Phys. Lett. 92, 03330 (2008).

CPP 43.9 Thu 16:15 H39

Total internal reflection microscopy: From scattering intensity to absolute position — •Thomas Brettschneider[1], Giovanni Volpe[1,2], Laurent Helden[1], and Clemens Bechinger[1,2] — [1]2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany — [2]Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany

Total Internal Reflection Microscopy (TIRM) is a sensitive and non-intrusive technique to measure the interaction potentials between a colloidal particle immersed in a liquid and a wall. The equilibrium distribution of the particle-wall separation distance z is sampled monitoring the intensity I scattered by the Brownian particle under evanescent illumination. From this one can determine the distance resolved interaction potential and corresponding forces with femtonewton resolution. The central point of the data analysis is the *a priori* knowledge of the relation between the measured scattering intensity I and the corresponding particle distance z. For short penetration depths of the evanescent field, it has been demonstrated that $I(z) \propto \exp(-z/\delta)$. This, however, poses considerable constraints to the experimental conditions and the range of forces where TIRM can be applied. Here, we introduce a method to experimentally determine $I(z)$ by making solely use of the distance-dependent hydrodynamic interactions between the particle and the wall. We demonstrate, that our method largely extends the range of conditions accessible with TIRM, and even allows measurements on highly reflecting gold surfaces where multiple reflections lead to large deviations from an exponential $I(z)$ relationship.

CPP 43.10 Thu 16:30 H39

Sliding of colloidal monolayers on periodic and quasiperiodic substrate potentials — •Thomas Bohlein, Jules Mikhael, and Clemens Bechinger — 2. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

Quasicrystal surfaces exhibit low friction coefficients. This anomalous property led to their consideration as coatings for tribological applications. However, the fundamental mechanisms behind this behavior are still not well understood. Here we experimentally study the sliding behavior of two dimensional colloidal crystals interacting with periodic and quasiperiodic light induced substrate potentials created by overlapping several laser beams. A precise control of the phases of the interfering beams allows us to shear the substrate potential against the crystal in any desired direction while the crystal's response is studied in real space by digital video microscopy. We study how the substrate strength, the sliding velocity and the matching of the length scales affect the sliding behavior. This allows us to identify the role of quasiperiodicity on the friction behavior which leads to a better understanding on the fundamentals of atomic fiction and superlubricity.

CPP 43.11 Thu 16:45 H39

Colloidal particles in microchannels: transport in confined geometries — •Christian Kreuter, Paul Leiderer, and Artur Erbe — University of Konstanz, Germany

Understanding of biological systems requires detailed knowledge of the transport behavior of interacting particles. Since real-life systems are typically very complex, experimentally easily accessible systems have to be investigated in order to understand the fundamental physics underlying the collective behavior. During the last years, studies of colloidal systems have become a standard approach to model and simulate real systems. In our experiments we use superparamagnetic particles and investigate the transport behavior of such interacting particles gravitationally driven through narrow channels defined by optical lithography. With this experimental system we can realize various potential shapes by crossings of channels or channels with structured walls. Furthermore we modify the transport behavior through realization of barriers perpendicular to the channel. These systems resemble, for example, transport through ion channels or electron transport in mesoscopic systems.

CPP 43.12 Thu 17:00 H39

Direct measurement of shear-induced cross-correlation of Brownian motion — •Andreas Ziehl and Christian Wagner — Universität des Saarlandes, Saarbrücken

Shear-induced cross-correlations between particle fluctuations perpendicular and along streamlines are investigated experimentally and theoretically in a linear shear flow. We used optical tweezers to localize one or two particles, each in a harmonic potential, and to detect the positions of the particles as a function of time with a high spatial precision below 8nm. These positions are recorded via a high speed camera with 15kHz resolution. In contrast to measurements in a quiescent fluid, we find that in shear flow, generated in a special designed micro fluidic device, orthogonal movements of a bead in stream- and gradient- directions are correlated and the time reversal symmetry is broken. Again in a quiescent fluid, fluctuations of two particles, separated by a few microns, are known to be anti-correlated along their connecting vector due to hydrodynamic coupling. In linear shear flow, we found a coupling process that correlates the orthogonal directions of the two particles. The correlation exhibits a minimum in time and again the time reversal symmetry is broken.

CPP 43.13 Thu 17:15 H39

Experimental accessible variables for testing a generalized fluctuation-dissipation theorem — •Jakob Mehl, Valentin Blickle, and Clemens Bechinger — 2. Physikalisches Institut, Universität Stuttgart, Germany

One cornerstone of statistical physics is the fluctuation-dissipation theorem (FDT). Generally true for all systems slightly perturbted around their equilibrium state, it connects the response of any observable to a small perturbation to equilibrium correlations involving the observable conjugated to the perturbation with respect to energy.

When leaving thermal equilibrium the FDT breaks down. Recently it was shown, that the FDT can be generalized to nonequilibrium steady states (NESS) by choosing the conjugated variable with respect to entropy. By combining colloidal particles, rotating laser tweezers, and video microscopy, we confirm experimentally the generalized FDT for a NESS. In principle the restored formulation allows infinitely many variants of the FDT. However, our experiments demonstrate, that the right choice of variables is crucial to determine the nonequilibrium response via forced fluctuations out of a NESS.

CPP 43.14 Thu 17:30 H39

Is there a Relationship between the Elongational Viscosity and the First Normal Stress Difference in Polymer Solutions? — •Stephan Gier[1], Andreas Zell[1], Salima Rafai[2], and Christian Wagner[1] — [1]Universität des Saarlandes, Saarbrücken — [2]Laboratoire de Spectrometrie Physique, Grenoble

We investigate polymer solutions in shear and elongational flow. Shear flow is created in a cone-plate-geometry of a commercial rheometer. The capillary thinning of a filament of polymer solution in the Capillary Breakup Extensional Rheometer (CaBER) serves as an elongational flow. We compare the relaxation time and the elongational viscosity measured in the CaBER with the first normal stress difference and the relaxation time from the rheometer measurements. All these four quantities depend on different fluid parameters - the viscosity of the polymer solution, the polymer concentration within the solution, and the molecular weight of the polymers - and on the shear rate (in the shear flow measurements). Nevertheless, we found that the first normal stress coefficient depends quadratically on the CaBER relaxation time. A simple model is presented that explains this relation on a phenomenological level.