CPP 20: Focus: Magnetic Soft Matter II

Time: Wednesday 9:30–12:30 Location: ZEU 222

Invited Talk CPP 20.1 Wed 9:30 ZEU 222

Truncated patterning in the normal field instability — •Andreas Boudouvis — School of Chemical Engineering, National Technical University of Athens, Athens 15780, Greece

The normal field instability sets in a pool of ferrofluid when the strength of a uniform magnetic field, applied in a direction normal to the horizontal free surface of the pool, exceeds a threshold.

Most studied in laterally unbounded pools, the instability gives way to spontaneously formed static patterns of spikes exhibiting striking spatial symmetry, usually hexagonal and rarely square [1, 2].

The finiteness of a pool introduces "imperfections", namely lateral pattern truncation along with side-wall wetting [3]. Of concern here is the normal field instability and the accompanying pattern formation in round containers of moderate diameter. Bifurcation diagrams of truncated patterns of two, three and four spikes are computed by solving the equations of the 3-D capillary magnetohydrostatics with the Galerkin/finite element method. The theoretical predictions, which are in good agreement with experimental measurements, reveal the structure of the solution space, namely the connectivity, the multiplicity and the stability of the truncated patterns, in the studied parameter "window", defined by varying applied field strength and container diameter.

[1] Cowley M D & Rosensweig R E 1967 J. Fluid Mech. 30, 671. [2] Gollwitzer C, Matthies G, Richter R, Rehberg I & Tobiska L 2007 J. Fluid Mech. 571, 455. [3] Boudouvis A G, Puchalla J L & Scriven L E 1988 J. Colloid Interface Sci. 124, 677.

CPP 20.2 Wed 10:00 ZEU 222

Structure of ferrofluid nanofilms in homogeneous magnetic fields — •Jelena Jordanovic and Sabine H. L. Klapp — Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin

We report molecular dynamic simulations for a model Stockmayer fluid confined between two plane, parallel walls and subject to an external homogeneous field. The occurring layers, which are characteristic for fluid nanofilms, can be controlled via the field such that for an appropriate film thickness a new layer is created in a perpendicular field while in a parallel field one layer can be destroyed [1]. This field-controlled layering modulation as well as formation of hexagonal or labyrinth in-plane patterns have also been observed in experiments [2,3] and are a promising route for designing novel materials. In our study we examine in detail the dependence of the field-induced structural changes in-plane and normal to the film surfaces on the thermodynamic state [4] for both field directions. Also, we inspect the influence of the attractive contribution of the Lennard-Jones potential on the structural behavior in field. Additionally we investigate a mono- to bilayer transition induced via a perpendicular field to relate our findings to quasi-two-dimensional systems.

[1] J. Jordanovic and S. H. L. Klapp, Phys. Rev. Lett. 101, 038302 (2008).
[2] A. Vorobiev et.al. Phys. Rev. Lett. 93, 267203 (2004).
[3] V. Germain et.al. J. Phys. Chem B 109, 5541 (2004).
[4] J. Jordanovic and S. H. L. Klapp, submitted.

CPP 20.3 Wed 10:15 ZEU 222

Ground state structures in ferrofluid monolayers: Theory and Simulations. — •Sofia Kantorovich[1,2], Victor Danilov[1], Taisia Prokopyeva[1], and Christian Holm[2] — [1]Ural State University, Ekaterinburg, Russia — [2]University of Stuttgart, Stuttgart, Germany

The investigation of the microstructure of ferrofluid monolayers at low temperatures was extended to bidisperse model systems. Previously we have shown that a single ideal ring is the most probable ground state structure for a monodisperse ferrofluid monolayer. Starting with system containing large particles we introduce small particles as defects, and analyze the resulting structures, using a combination of analytical methods and Monte Carlo simulations. The crucial influence of the interaction between particles from different fractions (namely, large and small ones) is demonstrated.

CPP 20.4 Wed 10:30 ZEU 222

Phase transitions and ordering of confined magnetic fluids in applied magnetic fields — •Istvan Szalai[1] and Siegfried Dietrich[2,3] — [1]Institute of Physics, University of Pannonia, H-8201 Veszprem, PO Box 158, Hungary — [2]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, Germany — [3]Institut für Theoretische und Angewandte Physik, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany

For the case of the presence of a magnetic field we apply a modified mean-field density functional theory to determine the phase behavior of magnetic fluids in slit-like pores formed by two parallel walls with identical substrate potentials. The magnetic fluid is modeled by the Stockmayer interaction potential. A Carnahan-Starling equation of state based fundamental-measure theory is employed to incorporate the effects of short-ranged hard sphere-like correlations while the long-ranged contributions to the fluid interaction potential are treated perturbatively. The ferromagnetic liquid - ferromagnetic vapor first-order phase transitions and the structural properties of both phases are investigated. The magnetization and susceptibility of the magnetic fluids are also studied. We discuss how the phase diagrams are shifted and distorted upon varying the field strength and the pore width.

CPP 20.5 Wed 10:45 ZEU 222

Gas–liquid critical behavior in fluids of soft-repulsive charged dumbbells — •Heiko Braun and Reinhard Hentschke — Fachbereich Mathematik und Naturwissenschaften, Bergische Universität Wuppertal, D-42097 Wuppertal, Germany

The existence of gas-liquid coexistence in dipolar fluids with no other contribution to attractive interaction than dipole-dipole interaction is a basic and open question in the theory of fluids. Recent MC work by Camp and coworkers [1] indicates that a fluid of charged hard dumbbells does exhibit g-l coexistence. This system has the potential to answer the above fundamental question, because the charge-to-charge separation d on the dumbbells may be reduced to, at least in principle, yield the dipolar fluid limit. Here we present MD results for the g-l phase behavior including the critical point of charged soft dumbbells for fixed dipole moment and fixed charges as function of d. We do find a g-l critical point at finite temperature for fixed dipole moment at small d. In this limit, however, we also find that the dumbbells form reversible networks so that the transition possibly is due to the mechanism suggested by Tlusty and Safran [2] for reversible networks.

[1] G. Ganzenmüller, P. J. Camp, J. Chem. Phys. 126, 191104 (2007)
[2] T. Tlusty, S. A. Safran, Science 290, 1328 (2000)

15 min. break

Invited Talk CPP 20.6 Wed 11:15 ZEU 222

Using triaxial magnetic fields to form optimized particle composites — •James Martin — Sandia National Laboratories, Albuquerque, New Mexico, USA

Complex dynamics can be induced in magnetic particle suspensions by subjecting them to three orthogonal alternating magnetic fields. The range of behavior that can be induced is broad, including particle vortex formation and oscillating sheet-like structures. When such particle suspensions are polymerized in the triaxial field, a variety of surprising structures form -such as particle honeycombs and chain networks - due to the interaction of the viscosity divergence with the heterodyne field frequencies. Such materials are found to have highly optimized magnetic properties and we have completed extensive Brownian Dynamics simulations to understand the emergence of structure in these materials.

CPP 20.7 Wed 11:45 ZEU 222

Shape Discrimination with Hexapole Dipole Interactions in Magic Angle Spinning Colloidal Magnetic Resonance. — Pietro Tierno[1], Steffen Schreiber[2], Walter Zimmermann[2], and •Thomas Fischer[2] — [1]University of Barcelona — [2]University of Bayreuth

We study the interactions between magnetically driven anisotropic and isotropic colloidal rotors interacting via induced magnetic dipolar and multipolar forces in a precessing magnetic field. Close to the magic precession angle dipole dipole interactions between the rotors can be tuned such that shape sensitive higher multipole moments allow to assemble originally spherical rotors into clusters of defined shape and

size.

CPP 20.8 Wed 12:00 ZEU 222

Brownian ratchet effect in a ferrofluid sample — •Thomas John and Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg, Germany

We investigate experimentally a Brownian ratchet system suggested by Engel et al. [1]. The Brownian ratchet system is based on a magnetic fluid which contains nanometer sized magnetic particles in a thermal bath of carrier fluid. An external static and perpendicular a temporal asymmetric oscillatory magnetic field acts on the particles. Depending on the parameter of this non-rotating field on a spherical ferrofluid sample the induced macroscopic torque is measured. A quantitative comparison of measured torques with predictions from a microscopic [2] and a phenomenological model from M. I. Shliomis [3] are given. Both models describe certain aspects of the measurements only in limited parameter ranges. Several qualitative discrepancies between these models and experiment are found.

[1] A. Engel et al., Phys. Rev. Lett. **91**, 060602 (2003).
[2] A. Engel et al., Phys. Rev. E **70**, 051107 (2004).
[3] M. I. Shliomis, Phys. Rev. Lett. **92**, 188901 (2004).

CPP 20.9 Wed 12:15 ZEU 222

Thermomagnetic convection in magnetic fluids influenced by spatially modulated magnetic fields — •Adrian Lange and Stefan Odenbach — Technische Universität Dresden, Institute of Fluid Mechanics, Chair of Magnetofluiddynamics, 01062 Dresden, Germany

The influence of a spatially modulated magnetic field on the convection in a horizontal layer of magnetic fluid bounded by isothermal nonmagnetic boundaries is analysed. Such a magnetic field is generated by a spatial modulation of the top and bottom boundary of the fluid layer. Depending on the sign of the relative phases between the modulations, the basic state, the behaviour of the critical Rayleigh number, and the character of the onset of convection is studied. With respect to the latter, it is of particular interest if a Hopf bifurcation can be found as for spatially periodic modulated Rayleigh-Bénard convection [1].

[1] R. Schmitz and W. Zimmermann, Phys. Rev. E **53**, 5993 (1996).