



# SFB TR6

Physics of  
Colloidal Dispersions  
in External Fields

# GEMEINDE BRIEF 2013

## Editorial

Welcome to the seventh and last issue of the annual SFB TR6 Gemeindebrief. This newsletter is a forum to present the recent research highlights and scientific activities of the collaborative research centre SFB TR6. It is directed both to researchers in the network and to other scientists interested in the physics of colloidal dispersions. The newsletter also includes a short personalia section and information about SFB TR6 and soft matter conferences, schools and workshops.

Those who want to know more about the SFB TR6 are invited to visit our web page: [www.sfb-tr6.de](http://www.sfb-tr6.de)

Hartmut Löwen and Brigitte Schumann-Kemp

## Final SFB-Meeting in Schloss Waldthausen



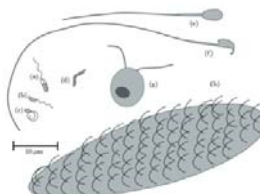
The final SFB Meeting was held in Schloss Waldthausen (close to Mainz) on March 5-7, 2013. 5 external guest were invited to present talks: E. Furst (Delaware), S. Klapp (Berlin), K. Mecke (Erlangen), K. Neyts (Gent), D. Norris (Zurich).

All projects were presenting talks and there were 22 additional poster contributions. Altogether this workshop had 92 participants. This meeting was in particular helpful to bring collaborations to an harvesting end. There was also an internal SFB member meetings to discuss strategies for the final report.



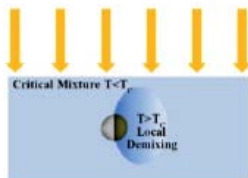
## DFG Priority Program on Microswimmers

In spring 2013, a new DFG Science Priority Program SPP 1726 with the topic "Microswimmers - From Single Particle Motion to Collective Behavior" was launched which is concerned both with biological and artificial colloidal swimmers. This SPP partially grew out of the SFB TR6. The new SPP 1726 is coordinated by Gerhard Gompper (Jülich). Among the eight initiators, five persons were former principle investigators of the SFB TR6 (G. Gompper, C. Bechinger, H. Löwen, H. Stark, R. Winkler). It is expected that the number of principle investigators will participate in this new SPP program. The knowledge about passive colloids in external fields will be essential to understand the dynamics of artificial swimmers.



## In this issue

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### The SFB TR6 Third Young Researcher Meeting (Konstanz)

The third Young Researcher Meeting of the third SFB funding period was held in Konstanz from September 10-12, 2012 and was organized by Peter Keim. About 24 young SFB scientists came together to present their own research.



### ELOPTO 2012 (Gent)

The 13th International Symposium on Colloidal and Molecular Electrooptics (ELOPTO) was organized by K. Neyts in September 2nd-5th 2012 in Gent (Belgium) under sponsoring of the SFB TR6. As usual, this meeting had a strong attendance of SFB scientists with T. Palberg as an invited speaker.



### Statistical Mechanics (Mainz)

The international meeting "Statistical Mechanics: Interplay of Theory and Computer Simulations" was held in Mainz, 19 - 21 September 2012, to honor Kurt Binder, who became emeritus at the University of Mainz in 2012. The three SFB members F. Schmid, B. Dünweg and K. Kremer were in the conference committee. This meeting has a big SFB attendance with H. Löwen being among the invited speakers.

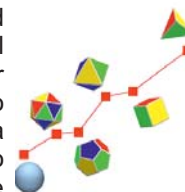


### Selected scientific results

#### Density Functional Theory for Hard Polyhedra

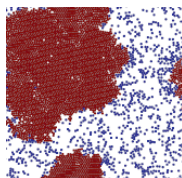
*M. Marechal, H. Löwen, PRL 110, 137801 (2013)*

Using the framework of geometry-based fundamental-measure theory, a classical density functional for hard polyhedra and their mixtures was developed and applied to inhomogeneous fluids of Platonic solids near a hard wall. As revealed by Monte Carlo simulations, the faceted shape of the polyhedra leads to complex layering and orientational ordering near the wall, which is excellently reproduced by the theory.



#### Dynamical Clustering and Phase Separation in Suspensions of Self-Propelled Colloidal Particles

*I. Buttinoni, J. Bialke, F. Kümmel, H. Löwen, C. Bechinger, T. Speck, PRL 110, 238301 (2013)*

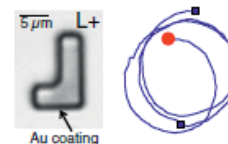


A (quasi-)two-dimensional colloidal suspension of self-propelled spherical particles was studied experimentally and numerically. The particles are carbon-coated Janus particles, which are propelled due to diffusiophoresis in a near-critical water-lutidine mixture. At low densities, the driving stabilizes small clusters. At higher densities, the suspension undergoes a phase separation into large clusters and a dilute gas phase. The observed behavior is rationalized in terms of a dynamical instability due to the self-trapping of self-propelled particles.

#### Circular Motion of Asymmetric Self-Propelling Particles

*F. Kümmel, B. ten Hagen, R. Wittkowski, I. Buttinoni, R. Eichhorn, G. Volpe, H. Löwen, C. Bechinger, PRL 110, 238301 (2013)*

Micron-sized self-propelled (active) particles can be considered as model systems for characterizing more complex biological organisms like swimming bacteria or motile cells. Asymmetric microswimmers by soft lithography and studied their circular motion on a substrate and near channel boundaries were produced. The experimental observations are in full agreement with a theory of Brownian dynamics for asymmetric self-propelled particles, which couples their translational and orientational motion.



#### Emergent self-propulsion at low Reynolds number

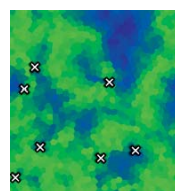
*A. Reinmüller, H.J. Schöpe, T. Palberg, Langmuir 29 (2013)*

An experimental realization of inanimate micro-swimmer complexes showing emergent self-propulsion at low Reynolds number in quasi 2D colloidal systems was proposed.



#### Two-dimensional melting under quenched disorder

*S. Deuschländer, T. Kruppa, H. Löwen, G. Maret, P. Keim, PRL (in press)*



In a collaboration between the projects C2 and C3, the influence of quenched disorder on the two-dimensional melting behavior was explored by using both video-microscopy of superparamagnetic colloidal particles and computer simulations of repulsive parallel dipoles. The occurrence of the Kosterlitz-Thouless-Halperin-Nelson-Young scenario is confirmed even under the presence of disorder.

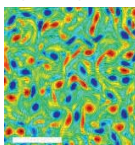


## Selected scientific results (continued)

**Meso-scale turbulence in living fluids**

H.H. Wensink, J. Dunkel, S. Heidenreich, K. Drescher, R.E. Goldstein, H. Löwen, J.M. Yeomans, *PNAS* **109**, 14308 (2012)

A new turbulent state in active systems was proposed as obtained by computer simulation, theory and experiments on bacillus-subtilis self-propelled rods.

**Crystalline multilayers of charged colloids in soft confinement: experiment versus theory**

E.C. Oguz, A. Reinmüller, H.J. Schöpe, T. Palberg, R. Messina, H. Löwen, *J. Phys.: Condens. Matter* **24** 464123 (2012)

We combine real-space experiments and lattice sum calculations to investigate the phase diagram of charged colloidal particles under soft confinement. In the experiments we explore the equilibrium phase diagram of charged colloidal spheres in aqueous suspensions confined between two parallel charged walls at low background salt concentrations.

**Residual Stresses in Glasses**

M. Ballauff, J.M. Brader, S.U. Egelhaaf, M. Fuchs, J. Horbach, N. Koumakis, M. Krüger, M. Laurati, K.J. Mutch, G. Petekidis, M. Siebenbürger, T. Voigtmann, J. Zausch, *PRL* **110**, 215701 (2013)

The history dependence of glasses formed from flow-melted steady states by a sudden cessation of the shear rate  $\dot{\gamma}$  was studied in colloidal suspensions, by molecular dynamics simulations and by mode-coupling theory.

**Packing Confined Hard Spheres Denser with Adaptive Prism Phases**

E.C. Oguz, M. Marechal, F. Ramiro-Manzano, I. Rodriguez, R. Messina, F.J. Meseguer, H. Löwen, *PRL* **109**, 218301 (2012)

Hard spheres confined between two parallel hard plates pack denser with periodic adaptive prismatic structures which are composed of alternating prisms of spheres. The adaptive prism phases are also observed in real-space experiments on confined sterically stabilized colloids and in Monte Carlo simulations at finite pressure.

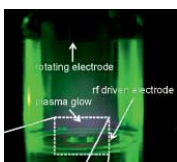
**Non-monotonic crossover from single-file to regular diffusion in micro-channels**

U. Siems, C. Kreuter, A. Erbe, N. Schwierz, S. Sengupta, P. Leiderer, P. Nielaba, *Nature - Scientific Reports* **2**, 1015 (2012).

In a collaborative work between projects C1 and C4 we studied the diffusion of colloidal systems in micro channels. When the density of the particles is changed, diffusion alternates between normal Fickian behavior and single-file diffusion on intermediate but long time scales. This anomalous behavior is induced by the order of the particles in the restricted geometry.

**Magnetizing a complex plasma without a magnetic field**

H. Kählert, J. Carstensen, M. Bonitz, H. Löwen, F. Greiner, A. Piel, *PRL* **109**, 155003 (1-5) (2012)

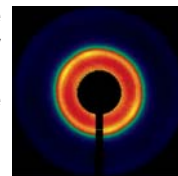


In collaboration with the SFB TR24 it was shown that the action of a strong magnetic field in a charged dusty plasma can be realized by a rotating electrode.

**Nonlinear Behavior of Nematic Platelet Dispersions in Shear Flow**

M.P. Lettinga, P. Holmqvist, P. Ballesta, S. Rogers, D. Kleshchanok, B. Struth, *PRL* **109**, 246001 (2012)

Dispersions of platelets in the nematic phase are submitted to large amplitude oscillatory shear flow and probed by high temporal resolution small angle x-ray scattering. The response displays rich dynamic and structural behavior.

**Vacancy-stabilized crystalline order in hard cubes**

F. Smalenburg, L. Fillion, M. Marechal, M. Dijkstra, *PNAS* **109** 17886 (2012)

The effect of vacancies on the phase behavior and structure of systems consisting of hard cubes using event-driven molecular dynamics and Monte Carlo simulations was examined. A first-order phase transition between a fluid and a simple cubic crystal phase that is stabilized by a surprisingly large number of vacancies was found.

**Micro-structure evolution of wall based crystals after casting of model suspensions as obtained from Bragg microscopy**

T. Palberg, M.R. Maaroufi, A. Stipp, H.J. Schöpe, *J. Chem. Phys.* **137**, 094906 (2012)

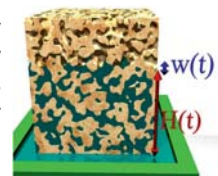


Growth of heterogeneously nucleated, wall based crystals plays a major role in determining the micro-structure during melt casting and was studied. Using a model system of charged colloidal spheres in deionized aqueous suspension observed by Bragg microscopy which is a combination of light scattering and microscopy were addressed.

**Anomalous front broadening during spontaneous imbibition in a matrix with elongated pores**

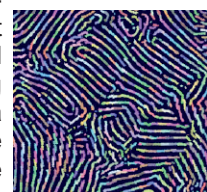
S. Gruener, Z. Sadjadi, H.E. Hermes, A.V. Kityk, K. Knorr, S.U. Egelhaaf, H. Rieger, P. Huber, *PNAS* **109**, 10245 (2012)

During spontaneous imbibition, a wetting liquid is drawn into a porous medium by capillary forces. Using experiments, a new universality class of imbibition behavior was proposed, which is expected to occur in any matrix with elongated, interconnected pores of random radii.

**Traveling and Resting Crystals in Active Systems**

A.M. Menzel, H. Löwen, *PRL* **110**, 055702 (2013)

A microscopic field theory for crystallization in active systems was proposed which unifies the phase-field-crystal model of freezing with the Toner—Tu theory for self-propelled particles. A wealth of different active crystalline states were predicted and characterized. In particular, for increasing strength of self-propulsion, a transition from a resting crystal to a traveling crystalline state was found where the particles migrate collectively while keeping their crystalline order.



Editorial Details

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Special among SFB TR6 guests

- 06/2013 **O. Vinogradova (Moscow, Russia)** visited Mainz
- 05/2013 **S.P. Das (New Delhi, India)** visited Düsseldorf
- 03/2013 **W. van Meegen (RMIT Melbourne, Australia)** visited Mainz/Düsseldorf
- 01/2013 **B. Cichocki (Warsaw, Poland)** visited Jülich
- 12/2012 **T. Ohta (Kyoto, Japan)** visited Düsseldorf
- 11/2012 **P. Young (Santa Cruz, USA)** visited Mainz
- 09/2012 **S. K. Das (Bangalore, India)** visited Mainz
- 06/2012 **I. Williams (Bristol, UK)** visited Düsseldorf

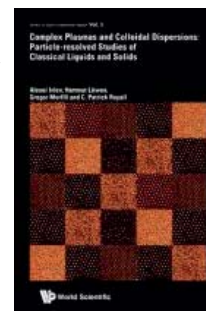
Special Publications

The SFB TR6 will publish its scientific final report as a special issue in the *European Physical Journal (Special Topics)* under guest editorship of J. K. G. Dhont, H. Löwen, P. Nielaba, T. Palberg and A. van Blaaderen. All projects of the last funding period will contribute a mini-review to this special issue. The issue is expected to appear end of 2013.



A special issue of the *Journal of Physics: Condensed Matter on "Colloidal Dispersions in External Fields"* was published in November 2012 (Volume 24, Number 46) containing more than 30 papers with fresh research results in conjunction with the CODEF III meeting. All SFB projects and many the invited CODEF III speakers contributed with a paper.

The book *"Complex plasmas and colloidal dispersions: particle-resolved studies of classical liquids and solids"* (by A.V. Ivlev, H. Löwen, G.E. Morfill, C.P. Royall) was published highlighting the connection between colloidal dispersions and complex plasmas.



Prizes and honors



**Alfons van Blaaderen** (Utrecht) became a new member of the Royal Netherlands Academy of Arts and Sciences (KNAW) in September 2013.



**Kurt Binder** (Mainz) was honored with the PhD title Dr. rer. nat. h. c. of the Faculty of Mathematical and Natural Science at the Heine-Heine University of Düsseldorf.

**Pavlik Lettinga** is appointed as a part-time professor at the KU Leuven (Belgium) since November 2012 in the Laboratory of Acoustics and Thermal Physics.



**Raphael Wittkowski** (project D3, Düsseldorf, now Edinburgh (UK)) received the prize for the best dissertation in the academic year 2012 at the Faculty of Mathematical and Natural Science at the Heine-Heine University of Düsseldorf.



**Thomas Speck** (project C3, Düsseldorf) has received a call on a professorship of Theoretical Physics at the Johannes Gutenberg- University of Mainz.

SFB Young Researcher Prize



The SFB TR6 created a prize for young researchers for which particularly creative collaborations were honored. The prize consists of an award and money to buy colloidal textbooks. The executive SFB TR6 board was the jury. Upon various nominations three candidates were selected as prize winners. **Dr. Marco Laurati** (in the middle) for his experiments on sheared colloidal suspensions, **Dr. Alexander Reinmüller** (on the left) for his experiments on confined charged colloids and **Dr. Alexander Winkler** (absent) for his computer simulations of colloidal fluids in confinement.

Obituary

We are sorry to announce that **Ian Snook** (RMIT, Melbourne), a long-term visitor and collaborator of the SB TR6, deceased in April 2013.

