Conference Report II

Jülich Soft Matter Days 2008

12–14 November 2008

Bonn, Germany

The Jülich Soft Matter Days were held at the Gustav-Stresemann-Institut in Bonn, Germany, from 12 to 14 November 2008. This conference is organized every year by J.K.G. Dhont, G. Gompper and D. Richter from the Forschungszentrum Jülich. The number of participants is limited to about 220, which ensures an informal atmosphere and avoids parallel sessions. An important part of the conference were two lively posters sessions with more than 120 contributions. For more information about the 2008 conference, see the webpage http://www.fz-juelich.de/iff/jsmd2008.

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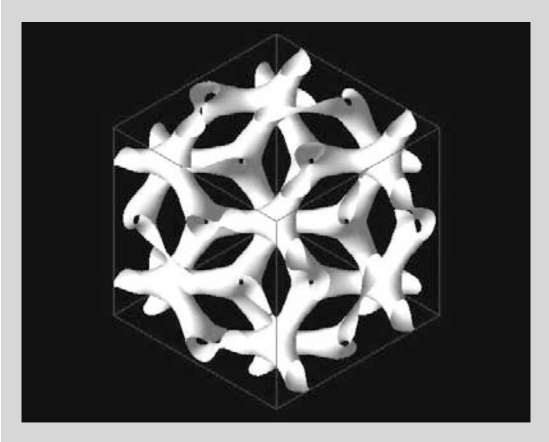

Figure 1: The double-gyroid structure that occurs in micro-phase separated diblock co-polymers.

The aim of these meetings is to bring together scientists from all soft matter disciplines and from biophysics. The systems of interest include colloidal dispersions, polymer-solutions, -mixtures and -melts, block copolymers, binary and ternary amphiphilic systems (microemulsions), membranes, vesicles and biological macromolecules. While many of these systems have already been investigated for a long period of time, only recently their common features and mixtures have come into focus. In addition, in recent years, systems with various types of complex particles have been studied, where the particles exhibit combined properties of colloidal, polymeric or amphiphilic character. For example, Janus colloids share features of colloids and amphiphiles, fd-viruses are in between rod-like colloids and stiff polymers, and star polymers bring together polymer solutions and colloidal systems. These highly complex systems are characterized by structural units with typical length scales ranging from nanometers to micrometers. The experimental and theoretical investigations as well as the understanding of the properties of these materials are highly challenging due to their high complexity, the large number of cooperative degrees of freedom, and the large range of relevant length, time and energy scales. This conference provided a forum to share and discuss the latest advances for the researchers in this field.

The sessions of the 2008 conference reflect the broad scope of the meeting, and addressed colloids, polymers, physics of the cell, proteins, self-assembly and hydrodynamics. The topics that have been discussed in the colloid session ranged from Archimedian tilings on quasi-crystalline surfaces (C. Bechinger, Stuttgart), multiple glassy states in star-polymer mixtures (Ch.N. Likos, Düsseldorf), and synthesis of nanoparticle-microgel composites (L.M. Liz-Marzan, Vigo), to buckling of microcapsules (A. Imhof, Utrecht), colloids at interfaces (W.K. Kegel, Utrecht) and dynamics of charged colloids (G. Nägele, Jülich).

In the polymer session, highlights included talks about capillary wrinkling of floating polymer films (T.P. Russell, Amherst), amplification of tension in branched polymers (M. Rubinstein, Chapel Hill), the physical and biological significance of transition in DNA (K. Yoshikawa, Kyoto), and the rheology of branched entangled polymer melts (D.J. Read, Leeds). In the session on physics of the cell, the main topics were the role of DNA conformations in gene control (R. Metzler, Munich), cell shapes and forces on patterned substrates (U. Schwarz, Karlsruhe), fiber organization in living cells (F. Nédélec, Heidelberg), and bacterial swarming (J. Vermant, Leuven). The main interests in the session on proteins were on neutron scattering to obtain information on structure (D.I. Svergun, Hamburg) and interdomain dynamics (R. Biehl, Jülich), NMR experiments and simulations on self-similar dynamics (G. Kneller, Orléans), and protein aggregation in chinese century eggs (E. Eiser, Cambridge).

Some of the topics of interest in the session on self-assembly were the kinetics of block-copolymer micelles (R. Lund, San Sebastian) and lipid vesicles (M. Nakano, Kyoto), rheology of microphase-separated diblock copolymers (T. Ohta, Kyoto), microscopic swimmers at surfaces (J. Elgeti, Jülich), and cytoskeleton dynamics of liposomes (C. Sykes, Paris). Finally, the session on hydrodynamics included talks on ordering of colloids by flow and sedimentation (M.J. Solomon, Ann Arbor), micro-fluidic crystals (R. Bar-Ziv, Rehovot), and heat and mass transport at interfaces (J.-L. Barrat, Lyon).

Amongst the above mentioned contributions, there are a number of talks that are of special interest to the rheology community. Three of such oral presentations will be discussed very briefly in the following.

Takao Ohta (Department of Physics, Kyoto University, Kyoto, Japan) presented his work on structural rheology of microphase separated diblock copolymers. Microphase separated diblock copolymers exhibit fascinating interconnected periodic structures such as a double-gyroid structure, as depicted in Fig. 1. Rheological measurements have been performed for such double-gyroid structures to probe the kinetics of morphological transitions. Although there is a fairly large number of computer simulations on the rheological behavior of microphase separated structures, most of the studies are limited to lamellar or hexagonal structures where domains are disconnected from each other. Ohta formu-

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Figure 2 (above): A swarming colony of the bacteria Pseudomonas aeruginosa atop a agar-agar substrate.

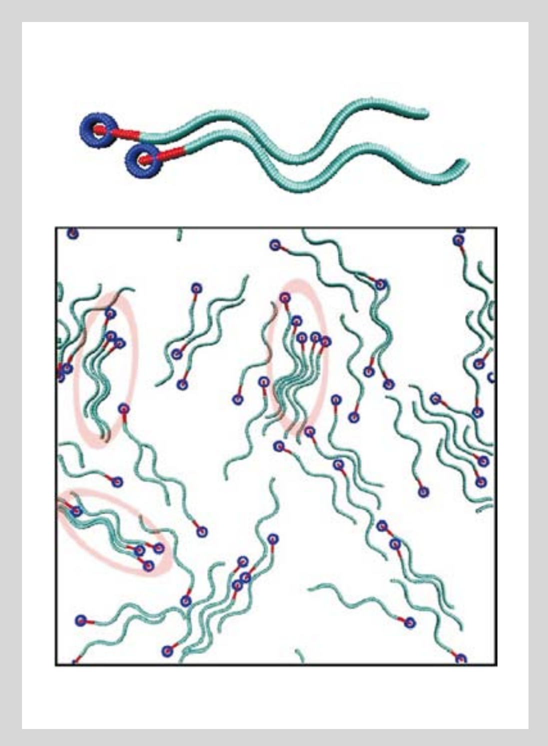

Figure 3: Two sperm swim in-phase and attract each other as a result of hydrodynamic interactions (upper figure). This leads to aggregation of several sperm at high concentrations (lower figure).

lated a viscoelastic theory for the double-gyroid structure in diblock copolymer melts within a coarse-grained approach. The energy increase and the energy dissipation due to the deformation of interconnected periodic domains caused by an oscillatory strain are evaluated by numerical simulations and a semi-analytical method. It is shown that a viscous response appears mainly due to local concentration fluctuations.

The striking pattern formation of swarming bacteria atop a solid substrate has been discussed by Jan Vermant (Department of Engineering, University of Leuven, Belgium). Bacterial swarming of colonies is typically described as a social phenomenon between bacteria. This multicellular behavior, during which the organized bacterial populations are embedded in an extracellular slime layer, is connected to important features such as biofilm formation and virulence. The swarming atop agar-agar substrates is accompanied by very striking pattern formation. Figure 2 shows a swarming colony of the bacteria Pseudomonas aeruginosa. Starting from the observation that several of the quorum sensing molecules, essential in swarming systems, are strong biosurfactants, the possibility of flows driven by gradients in surface tension has been proposed as an alternative to chemotaxis/reaction-diffusion models. Marangoni flows are known to lead to these characteristic patterns for the spreading of viscous drops under the action of a surfactant. The thickness of the films and spreading velocities have been measured and the results have been compared to the predictions of a thin film hydrodynamic model. A critical prediction is that the height of the colony should increase near the edges, which is indeed found in experiments.

Jens Elgeti (Institut für Festkörperforschung, Forschungszentrum Jülich, Germany) presented recent work on microscopic swimmers at surfaces. Both in soft matter and in biology, there are numerous examples of swimmers and self-propelled particles, which have a typical size in the range of a few nano- to several micro-meters, so that both low-Reynolds-number hydrodynamics and thermal fluctuations are essential to determine their dynamics. Examples include sperm cells (which are propelled by a snake-like beating of their tails), bacteria like E. coli, and synthetic self-propelled particles like bimetallic nanorods. Elgeti employed mesoscale hydrodynamics simulations to study individual sperm cells and self-propelled nanorods near surfaces, but also aggregation of sperm at high concentrations (see Fig. 3). He showed that both the rod-like shape of the swimmers and hydrodynamic interactions are responsible for the adhesion of single swimmers to surfaces and the cluster formation at higher concentrations. In systems of many sperm cells, the cluster size is found to depend strongly on the distribution of beating frequencies.

We hope that the Jülich Soft Matter Days will continue to be successful as an inter-disciplinary meeting on soft matter and biophysics. The next Jülich Matter Days will be held in Bonn in November 2009.

Jan K.G. Dhont, G. Gompper, D. Richter
j.k.g.dhont@fz-juelich.de

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