CPP 17: SYMPOSIUM Driven Soft Matter II

Time: Tuesday 14:00–16:00 Location: C 130

Invited Talk CPP 17.1 Tue 14:00 C 130

Soft Matter under Flow — •Gerhard Gompper — Institut für Festkörperforschung, Forschungszentrum Jülich, D-52425 Jülich, Germany

The dynamics of soft matter systems – such as colloidal suspensions, polymer solutions, and suspensions of fluid vesicles or cells – is often dominated by the hydrodynamic behavior of the solvent. For example, the flow properties of blood in micro-vessels is determined by the rheological properties of the red blood cells, and polymers unfold, tumble and collapse in shear flow. Furthermore, microfluidic devices allow the manipulation of small amounts of suspensions of particles or cells.

Multi-particle collision dynamics (MPC), a particle-based off-lattice mesoscopic simulation techniques has been shown be able to bridge the large length- and time-scale gap between the atomic and the mesoscopic domain in soft matter systems, and to describe hydrodynamic interactions at low Reynolds numbers very well [1]. In particular, it has then be applied recently to study the dynamical behavior of fluid vesicles and model red blood cells both in shear and capillary flows [2].

[1] M. Ripoll, K. Mussawisade, R.G. Winkler and G. Gompper, Europhys. Lett. **68**, 106 (2004); I.O. Götze, H. Noguchi, and G. Gompper, Phys. Rev. E **76**, 046705 (2007).
[2] H. Noguchi and G. Gompper, Phys. Rev. Lett. **93**, 258102 (2004); Proc. Natl. Acad. Sci. USA **102**, 14159 (2005); Phys. Rev. Lett. **98**, 128103 (2007).

Invited Talk CPP 17.2 Tue 14:30 C 130

Viscoelasticity of gels — •Annette Zippelius and Peter Müller — Institut für Theoretische Physik, Georg-August-Universität, D-37077 Göttingen

We study shear relaxation of randomly crosslinked macromolecular networks. The sol phase is characterized by a stretched exponential decay of shear relaxation, which can be traced to the random connectivity of molecular clusters such that weakly connected regions dominate the relaxation of shear. The transition from the sol to the gel is - like the glass transition - characterized by a diverging static shear viscosity, if the transition point is approached from the fluid side, respectively by a vanishing shear modulus, if the approach is from the amorphous solid side. The critical behaviour can be calculated exactly within the Rouse model, including the coefficients of normal stresses. A variational principle can be used to derive an exact lower bound for the static shear viscosity in the presence of excluded volume interactions. The divergence of the lower bound is stronger than in the Rouse model, proving the relevance of excluded volume interactions for the dynamic critical behaviour.

CPP 17.3 Tue 15:00 C 130

Giant DNA Diffusion — •Ralf Eichhorn, Jan Regtmeier, Alexandra Ros, Dario Anselmetti, and Peter Reimann — Universität Bielefeld, Fakultät für Physik, D-33615 Bielefeld

It has been predicted theoretically that particle diffusion in non-equilibrium systems can be enhanced by orders of magnitude, for instance, when the particle is moving in a periodic potential and the non-equilibrium conditions are established by an external static (tilting) force [1,2]. Recently, this effect has been demonstrated experimentally for colloidal particles [3]. We investigate this phenomenon experimentally and theoretically for λ (48.5 kbp) and T2 (164 kbp) DNA in a structured microfluidic device. The periodic potential landscape is created by electrodeless dielectrophoresis, and the tilting force is realized by electrophoresis. The observed giant diffusion is sensitive to the length of the DNA-fragment, and thus has potential application in DNA purification.

[1] P. Reimann, C. Van den Broeck, H. Linke, P. Hänggi, J.M. Rubi, and A. Perez-Madrid, Phys. Rev. Lett. **87**, 010602 (2001).
[2] P. Reimann, C. Van den Broeck, H. Linke, P. Hänggi, J.M. Rubi, and A. Perez-Madrid, Phys. Rev. E **65**, 031104 (2002).
[3] S. H. Lee, D. G. Grier, Phys. Rev. Lett. **96**, 190601 (2006).

CPP 17.4 Tue 15:15 C 130

Are we built of glass? — •Klaus Kroy[1,3], Pablo Fernandez[2], Jens Glaser[1], Christian Hubert[1], Sebastian Sturm[1], and Lars Wolff[1] — [1]Universität Leipzig, Leipzig, Germany — [2]Technische Universität München, Garching, Germany — [3]Hahn-Meitner Institut, Berlin, Germany

Recently B. Fabry and J. Fredberg [1] discovered that biological cells fall into the broad class of materials exhibiting 'soft glassy rheology' [2]. The glassy wormlike chain (GWLC) is a minimal extension of the standard WLC model of a stiff biopolymer, which establishes a link between this observation and the microscopic interactions of the polymeric constituents of the cytoskeleton [3]. Some of its major predictions for the nonlinear and non-equilibrium mechanical response of biopolymer networks to large driving forces will be outlined and compared to experimental data. On this basis, fundamental aspects of mechano-transduction, nonlinear cell elasticity and plasticity become accessible to theory.

[1] Fabry B, Maksym G. N, Butler J. P, Glogauer M, Navajas D, Fredberg J. J., Phys. Rev. Lett. 87 (2001) 148102
[2] Sollich P, Lequeux F, Hebraud P, Cates M. E., Phys. Rev. Lett. 78 (1997) 2020.
[3] arXiv:0705.049, arXiv:0711.2427

CPP 17.5 Tue 15:30 C 130

Entangled Dynamics of a Stiff Polymer — •Thomas Franosch, Felix Höfling, Tobias Munk, and Erwin Frey — Arnold Sommerfeld Center for Theoretical Physics and Center for NanoScience (CeNS), Department of Physics, Ludwig-Maximilians-Universität München, Theresienstrasse 37, D-80333 München, Germany

Entangled networks of stiff biopolymers exhibit complex response, emerging from the topological constraints that neighboring filaments impose upon each other. The relevant dynamic processes cover many decades in time, posing a tremendous challenge both to experiments and simulations. Pioneered by Edwards and de Gennes, the many-filament interaction was condensed in the picture of reptation in a confining tube. To achieve progress beyond simple scaling arguments, we propose a class of reference models for entanglement dynamics that allows us to provide a quantitative foundation of the tube concept for stiff polymers. For the fundamental limiting case of an infinitely thin needle exploring a planar parcours of point obstacles, we have performed large-scale simulations. Our results unambiguously prove the conjectured scaling from the fast transverse equilibration to the slowest process of orientational relaxation. In the highly entangled regime, the slow dynamics becomes attainable by employing a novel simulation algorithm based on interval analysis. We determine the rotational diffusion coefficient of the tracer, its angular confinement and the tube diameter. In addition, the tube concept is extended to a theoretical description of the complete orientational dynamics including a two-step relaxation, which is corroborated by our simulation results.

CPP 17.6 Tue 15:45 C 130

Flow NMR of polymers in external fields — Ute Böhme, Frank Bagusat, and •Ulrich Scheler — Leibniz Institute of Polymer Research Dresden, Hohe Str. 6, D-01069 Dresden

Pulsed-field gradient NMR is applied to study the motion of polymers in an external electric field and under mechanical shear. The application of an electric field drives motion of charged species. In conjunction with the diffusion coefficient from th electrophoreitc mobility the effective charge per molecule is derived [1-3]. The electric field applicable in the aqueous system is too weak to deform the polymer or even abstract counterions.

In a shear flow established in a Couette cell partial orientation of polymer chains is measured via residual dipolar couplings. The entire flow field in a non-symmetric flow cell is monitored by a combination of PFG NMR and NMR imaging exhibiting regions of high shear and locally low shear, where polymers relax [4].

[1] U. Böhme, U. Scheler, Colloids and Surfaces A, 222, (2003), 35 [2] U. Böhme, C. Vogel, J. Meier-Haack, Us. Scheler, J. Phys. Chem. B 111, (2007), 8344 [3] U. Böhme, U. Scheler, Journal of Colloid and interface science 309, (2007), 231 [4] A. Gottwald, U. Scheler, Polymer Preprints, 44, (2003), 273