# AKB 15 Cell Mechanics and Rheology

Zeit: Freitag 11:30–13:15 Raum: TU H2013

## Hauptvortrag

AKB 15.1 Fr 11:30 TU H2013

**Cellular mechanics investigations with holographic optical tweezers** — •Jennifer Curtis, Christian Schmitz, and Joachim Spatz — Biophysical Chemistry Group, Institute for Physical Chemistry, University of Heidelberg, Im Neuenheimer Feld 253, 69120 Heidelberg, Germany

Cells utilize exquisite control mechanisms for the production and organization of various molecules to maintain their own mechanical viability. How cells manifest this control and how these materials enable the mechanical outcome are key questions. One example is the biochemical control of the actin cortex and actin stress fibers for cell motility. Another is the expression of the gel-like pericellular matrix for gross modulation of surface adhesion. Another is the spontaneous fusion of vesicles to finely adjust and maintain plasma membrane tension. This talk will present the development and use of holographic optical tweezers (HOTs) for several cell biophysical applications including studies of the actin cortex, the pericellular matrix, and the membrane reservoir in the context of both their physical and biological questions. In particular, HOTs ability to selectively position measurement probes at the cell surface, the measurement of local tension and/or viscoelasticity at several points simultaneously, and the non-invasive detection of cell components will be described.

AKB 15.2 Fr 12:00 TU H2013

**A Characteristic Relaxation Time of Suspended Cells Revealed by Optical Rheology** — •Falk Wottawah, Stefan Schinkinger, Bryan Lincoln, Maren Romeyke, Josef Käs und Jochen Guck — Institute for Soft Matter Physics, University of Leipzig, Linnéstrasse 5, 04103 Leipzig

The measurement of the mechanical properties of individual cells has received much attention in recent years. Whole cell rheology of individual suspended fibroblasts in an optical stretcher displays a single passive relaxation, arising from transiently crosslinked polymers. This result is in stark contrast to recent rheological measurements on adherent cells. The measured frequency-dependent complex shear modulus reveals characteristic viscoelastic signatures of the underlying cytoskeleton and its dynamic microscopic properties. These are consistent with an isotropic actin cortex underlying the cellular plasma membrane. The elastic to fluid transition occurs at a relaxation time of 2.8±0.5 s, coinciding with unbinding times of actin crosslinking proteins. Elastic contributions from slowly relaxing entangled actin filaments are negligible. The symmetrical geometry of suspended cells, in contrast to adherent cells, ensures a minute statistical variability. Yet, distinctive viscoelastic features between different cell types are seen. Mechanical stimuli on longer time scales of minutes trigger active structural responses with internal forces on the order of 1 nN.

AKB 15.3 Fr 12:15 TU H2013

**Spektroskopie aktiver Zellkräfte mittels SFM** — •Claudia Brunner[1], Allen Ehrlicher[1], Michael Gögler[1], Bernd Kohlstrunk[1], Detlef Knebel[2] und Josef Käs[1] — [1]Universität Leipzig, Experimentelle Physik I, Physik weicher Materie, Linnéstr 5, 04103 Leipzig — [2]JPK Intruments, Bouchéstr 12, 12435 Berlin

SFM Messungen an biologischen Proben beschränken sich bisher auf die Bildgebung durch Abscannen und auf die Bestimmung elastischer und viskoelastischer Eigenschaften durch Kraft-Abstandskurven. Diese Verfahren ermitteln nur passive Materialeigenschaften und werden so dem lebendigen Charakter dieser Objekte nicht gerecht. Zellen sind in der Lage, aktiv Kräfte aufzubauen, um sich z.B. durch Gewebeverbände bewegen zu können. Das SFM hat die geeignete Sensitivität im nN-Bereich um diese Kräfte zu bestimmen. Eine auf eine Cantileverspitze geklebte Polystyrolkugel wird im Weg einer sich bewegenden Zelle positioniert. Die Zellen, hier Keratozyten bewegen sich unter deutlicher Verformung unter der Kugel hindurch. Der so ausgelenkte Cantilever detektiert die vertikal wirkende Kraft, die es erlaubt, die Vorwärtkräfte der Zellen zu berechnen. Im gemessenen Signal sind Lamellopodium und Zellkörper gut zu unterscheiden. Erst wenn die Kraft, mit der die Kugel auf den Boden drückt, zu groß ist, wird die Zelle gebremst. Diese Methode der Kraftmessung wird ausführlich beschrieben.

AKB 15.4 Fr 12:30 TU H2013

**Stiff Polymers, Foams and Fibre Networks** — •Claus Heussinger and Erwin Frey — Hahn-Meitner Institut, Berlin

The linear elastic properties of cellular materials like open cell foams are readily understood when considering stretching or bending compliance of a single cell. On the contrary, fibrous materials, for example the paper you most likely read this abstract from, are considerably more complicated because of the relevance of the additional scale of the fibre length $l_f$. While stretching dominated systems remain foam-like, bending dominated networks show collective effects with a highly non-affine strain field that cannot be explained by single cell properties.

In this work we will be concerned with two-dimensional networks of stiff polymers, that differ from the purely *mechanical* fibres ($T = 0$) in having an *entropic* stretching compliance. We show that upon addition of these thermal effects, it is the foam-like stretching dominated regime that is unstable, giving way for an intermediate asymptotic region with a non-trivial mixing of the bending and the stretching mode.

The numerical results can be explained by taking into account the whole distribution of stretching compliances of the polymer strands. In contrast to the importance of the *average cell* in purely enthalpic models, the polymer networks are dominated by the (fat) *tails* of the distribution which are of Levy-index $\mu = 5/4$.

AKB 15.5 Fr 12:45 TU H2013

**One-Bead Microrheology with Rotating Particles** — •Holger Stark and Michael Schmiedeberg — Universität Konstanz, Fachbereich Physik, D-78457 Konstanz

We lay the theoretical basis for one-bead microrheology with rotating particles, i.e, a method where colloids are used to probe the mechanical properties of viscoelastic media. Based on a two-fluid model, we calculate the compliance and discuss it for two cases. We first assume that the elastic and fluid component exhibit both stick boundary conditions at the particle surface. Then, the compliance fulfills a generalized Stokes law with a complex shear modulus whose validity is only limited by inertial effects, in contrast to translational motion. Secondly, we find that the validity of the Stokes regime is reduced when the elastic network is not coupled to the particle.

AKB 15.6 Fr 13:00 TU H2013

**Mapping Vortex Diffusion in Viscous and Visoelastic Fluids** — •Maryam Atakhorrami[1], Gijsberta H. Koenderink[2], Daisuke Mizuno[1], Frederick C. MacKintosh[1], and Christoph F. Schmidt[1] — [1]Dept. Physics, Vrije Universiteit, Amsterdam, NL — [2]Dept. Physics, Harvard University, Cambridge, MA, USA

One of the fundamental questions in hydrodynamics is the response of liquids to the displacement of a small immersed object. At low Reynolds numbers the velocity response of a simple liquid at a distance r from a point force is long-ranged, varying as 1/r. This "Stokes" flow accurately describes the motion of micron-size objects in water on time scales longer than a few microseconds. Over short times, however, the inertia of the liquid prevents the long-range stress propagation implicit in Stokes flow, and the disturbance of the fluid remains confined to a small region. In incompressible liquids this must involve back flow, i.e. a ring vortex is set up, which diffuses away from the point disturbance leaving in its wake the usual Stokes flow. Simulations and theoretical studies have demonstrated this phenomenon, while experiments have only observed indirect consequences, e.g. the "long-time tail" in scattering experiments. We have directly resolved the spatio-temporal structure of such vortices by measuring correlated thermal fluctuations and driven motions of micron sized particles in viscous and viscoelastic media at high frequency (100kHz). We find good agreement between experimental flow patterns and theoretical calculations for simple viscous fluids. Furthermore, we show how the vortex-like propagation is modified in viscoelastic media.