BP 32: Posters: Physics of Cells

Time: Thursday 17:15–20:00 Location: Poster B1

BP 32.1 Thu 17:15 Poster B1

Intra- and intercellular fluctuations in Min protein dynamics decrease with cell age — •Elisabeth Fischer-Friedrich[1], Giovanni Meacci[2], Joe Lutkenhaus[3], Hugues Chate[4], and Karsten Kruse[5] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany — [2]IBM T. J. Watson Research Center, P.O. Box 218, Yorktown Heights, NY 10598 — [3]Department of Microbiology, Molecular Genetics, and Immunology, University of Kansas Medical Center, Kansas City, Kansas 66160 — [4]CEA-Saclay, Service de Physique de l'Etat Condensé, 91191 Gif-sur-Yvette, France — [5]Theoretische Physik, Universität des Saarlandes, Postfach 151150, 66041 Saarbrücken, Germany

Self-organization of proteins in space and time is of crucial importance for the functioning of cellular processes. Often, this organization takes place in the presence of strong random fluctuations due to the small number of molecules involved. We report on stochastic switching of the Min-protein distributions between the two cell-halves in short *Escherichia coli* cells. A computational model provides strong evidence that the macroscopic switching is rooted in microscopic noise on the molecular scale. In longer bacteria, the switching turns into regular oscillations that are required for positioning of the division plane. As the pattern becomes more regular, cell-to-cell variability also lessens, indicating cell age-dependent regulation of Min-protein activity.

BP 32.2 Thu 17:15 Poster B1

High-speed dynamics of helical bacteria trapped in a light tube. — •Matthias Koch and Alexander Rohrbach — University of Freiburg, Georges-Koehler-Allee 102, 79110 Freiburg, Germany

The helical bacterium spiroplasma melliferum is a wall-less bacterium, where genome reduction has left these bacteria with a minimal set of genes - sufficient for independent life and self-reproduction. As a consequence they have an extreme structural simplicity and are among the smallest cells in size (˜200nm thin, 3-5μm long). However, they infect various plants and insects and thereby do tremendous harm to agriculture industry. Their motility, defined by helicity changes, kinking and propelling is very complex, and enables propagation in complex environments. However, it is unclear how this ˜500 gene machine works. Which molecular motors and which filament proteins cooperate at which forces on which time scales? What are the energetic of this apparatus and how do they change during external disturbances. We try to answer these questions by optically trapping the whole bacterium in a light tube, which consists of a high speed scanning line optical trap. Although propelling and kinking, the bacterium remains in the focal plane and can thereby be observed with video microscopy. In addition, trapping light scattered at the slopes of the helix gives precise 3D information about its dynamics, which is analyzed and modelled with Fourier-techniques. We show experimental results, including energies and forces involved in motility, and compare them to simulation data. Further, we present a first model of how this minimal machine could work and which amount of power it needs for self-propulsion.

BP 32.3 Thu 17:15 Poster B1

Elucidating the interaction of misfolded proteins with the quality control machinery in the endoplasmic reticulum — •Nina Malchus and Matthias Weiss — DKFZ, Heidelberg, Germany

A multitude of transmembrane proteins enter the endoplasmic reticulum (ER) as unfolded polypeptide chains. During their folding process they interact repetitively with the ER's quality control machinery. Here, we have used fluorescence correlation spectroscopy to probe these interactions for a prototypical transmembrane protein, tsO-45-G, in vivo [1]. While both, folded and unfolded tsO-45-G showed anomalous diffusion, the unfolded protein had a significantly stronger anomaly. This difference subsided when unfolded tsO-45-G was in a complex with its chaperone calnexin, or when a mutant form of tsO-45-G with only one glycan was used. Our experimental data and accompanying simulations suggest that the folding sensor of the quality control (UGT1) oligomerizes unfolded tsO-45-G, leading to a more anomalous/obstructed diffusion. In contrast, calnexin dissolves the oligomers, rendering unfolded tsO-45-G more mobile, and hence prevents poisoning of the ER. Additionally, we performed computer simulations to investigate the origin of the spread in the anomaly obtained from FCS experiments on membranes [2].

[1] N. Malchus & M. Weiss, submitted.
[2] N. Malchus & M. Weiss, J. Fluoresc., in press.

BP 32.4 Thu 17:15 Poster B1

Cell Monolayer Rheology — •Mathias Sander and Albrecht Ott — Biologische Experimentalphysik, Universität des Saarlandes, Saarbrücken

The mechanics of living cells is a major determinant of cell behaviour (e.g. in wound healing, cell differentiation). Understanding its underlying principles would add to cell biology, medicine and biophysics. Here we use "Cell Monolayer Rheology (CMR)", which determines the properties of a monolayer of approximately 10^6 cells with the help of a commercial rheometer. This allows us an improved definition of cell-mechanical responses. As for dead matter, it is often assumed that cells respond linearly within certain ranges of mechanical stimuli. However, the highly complex and dynamic structure of the cytoskeleton, which mainly governs the cellular mechanical properties, suggests a more subtle mechanical behaviour. Therefore, in our experiments, we focus on the non-linear response of a cell monolayer. Another important topic is the rheological study of inorganic layers as adhesion-promoting surface coatings. These can serve as an alternative to usual protein coatings. We investigate the different coatings with respect to their adhesion properties using the CMR-technique.

BP 32.5 Thu 17:15 Poster B1

The contribution of microtubules to the mechanical properties of cells — •Kenechukwu David Nnetu, Tobias Kiessling, Roland Stange, Anatol Fritsch, and Josef Käs — University of Leipzig, Institute of Experimental Physics I, Linnéstr. 5, 04103, Leipzig

A cell as a complex system is made up of various subcellular structures that allows it to sense and react to its environment. While alot of studies on the mechanical properties of cells have been done with adherent cells, little is known about the behaviour of cells in suspension. Although the state of suspension is not the most physiological, cells do sometimes find themselves in suspension for example during cancer metastasis as they move to other parts of the body through the blood and lymph vessels . Using the microfluidic optical stretcher that probes the mechanical properties of cells in suspension we studied the effect of the drugs Taxol and Latrunculin A. This allows a deeper insight into the contribution of microtubules to cellular mechanics.

BP 32.6 Thu 17:15 Poster B1

The automated Microfluidic Optical Stretcher — •Roland Stange, Tobias Kiesling, Bernd Kohlstrunk, and Josef A. Käs — University of Leipzig, Institute of Experimental Physics I, Linnestr. 5, 04103 Leipzig

Measuring the deformability of biological cells can be done in different ways. The most accurate one is the optical deformability measurement with the microfluidic optical stretcher. Due to the optical differences of each single living cell the scattering of the result has to be compensated with large numbers of measurements. According to the fact that the optical stretcher is operating with suspended cells in microfluidic channels it is complicated to handle by hand and time consuming to get precise and reliable data.

To improve the way of measuring the optical deformability we fully automated the optical stretcher by using a Labview program to control the flow pumps, the lasers and the camera. The produced data is then automatically evaluated by a Matlab program which finds out the deformation values from the images by an edge detection process. Furthermore the computer controlled microfluidic and photo lithographic produced measure chambers allow us to get different parameters out of the cell and sort them after measurement in a precisely controllable way.

BP 32.7 Thu 17:15 Poster B1

Living cell interactions with nanostructures — •Felix Keber, Philipp Paulitschke, Eva Weig, and Doris Heinrich — Fakultät für Physik und CeNS, LMU München, Germany

Cellular function is triggered by intracellular signaling cascades on small temporal and spatial scales. One prime example is cell migration,

a process which is induced by actin polymerization, and which results in cellular force exertion in three dimensional environments. Cell migration reflects the cellular microarchitecture, as a complex interplay of cellular force exertion by actin polymerization pattern dynamics. We investigate interactions of living cells with top-down-fabricated micro- and nanostructures. Our focus is set on the change in intracellular actin distribution as a reaction to our structured sample.

BP 32.8 Thu 17:15 Poster B1

Relating Cell Deformability to Cell Migration — •Franziska Lautenschlaeger[1], Joakim da-Silva[1], Michael Beil[2], and Jochen Guck[1] — [1]Dep. of Physics, University of Cambridge, UK — [2]Dep. of Internal Medicine I, University of Ulm, Germany

Mechanical properties of cells, mainly defined by the cytoskeleton, are closely related to cell function and can be measured with a dual-beam laser trap (Optical Stretcher). Functional changes which go hand in hand with changes of the cytoskeleton also occur during differentiation of stem cells. This suggests monitoring differentiation by the changing mechanical deformability of the cells. As a proof of principle, we compared the deformability of a haematopoietic precursor cell line (NB4) to ATRA differentiated NB4 cells. The differentiated cells were significantly softer. Surprisingly, the deformation behaviour of ATRA differentiated NB4 cells was not altered after treatment with the microtubule stabilizing drug Paclitaxel. In contrast, the relaxation after stress application changed significantly. In order to relate these rheology experiments to cell migration, all three cell types were observed migrating into 5um large channels. It was observed that undifferentiated NB4 cells were not able to migrate into these channels, contrary to differentiated NB4 cells and cells treated with taxol. Differences between the two latter have been found in the time the cells needed to migrate fully into the channel. This result correlates cell deformability measurements and cell migration measurements and might constitute an explanation for a syndrome occurring in leukemia patients after treatment with ATRA.

BP 32.9 Thu 17:15 Poster B1

Mechanosensing by neurons and glial cells — •Kristian Franze[1,2], Hanno Svoboda[2], Pouria Moshayedi[1,3], Andreas F. Christ[1], James Fawcett[3], Christine E. Holt[2], and Jochen Guck[1] — [1]Department of Physics, Cavendish Laboratory, University of Cambridge, UK — [2]Department of Physiology, Development and Neuroscience, University of Cambridge, UK — [3]Brain Repair Center, University of Cambridge, UK

Nervous tissue is densely packed with different types of cells. All these building blocks differ in their mechanical properties. Here we show how neurons and glial cells respond to the compliance of their environment. Primary retinal ganglion cells, astrocytes, and microglia were cultured on polyacrylamide gels with shear moduli between 0.1 and 30 kPa, and quantitative morphometric analysis was used to evaluate cell responses to the mechanically different substrates. While astrocytes and microglia cultured on stiffer substrates showed increased perimeter, area, diameter, elongation, number of extremities and overall complexity if compared to those cultured on more compliant substrates, the lengths and branching patterns of neuronal processes were not significantly changed. However, when cultured on substrates with a stiffness gradient, neurons preferentially grew towards soft. The observed cellular behavior may explain why glial scars formed after traumatic injury to the central nervous system impede neuronal regeneration. Ultimately, this impediment might be circumvented by using neural implants that incorporate mechanical properties based on our findings.

BP 32.10 Thu 17:15 Poster B1

Integrin alpha5beta1 increased cell invasion through enhanced contractile forces — •Claudia Tanja Mierke[1], Benjamin Frey[3], Martina Fellner[1], Martin Herrmann[2], and Ben Fabry[1] — [1]University of Erlangen, Biophysics Group — [2]University Hospital Erlangen, Dpt. Internal Medicine III — [3]University Hospital Erlangen, Dpt. Radiation Oncology

Cell motility is a fundamental biomechanical process in tumor growth and metastasis formation. Cell migration through dense connective tissue usually requires firm adhesion to the extracellular matrix through integrins. For some tumors, increased integrin expression is associated with increased malignancy and metastasis formation. Here, we studied the invasion of cancer cells with different a5b1 integrin expression levels into dense 3-D collagen fiber matrices. Using a cell sorter, we isolated a5b1-high and a5b1-low expressing sub cell lines from parental MDA-MB-231 breast cancer cells. Cells with higher a5b1 expression showed significantly (3-fold) increased cell invasiveness, whereas knock-down of the a5 integrin subunit lead to decreased tumor cell invasion. Interestingly, knock-down of the collagen receptor integrin subunit a1 did not alter invasiveness, indicating that the effect is integrin-type specific. Fourier transform traction microscopy revealed that the a5b1-high expressing cells generated 5-fold larger contractile forces. Cell invasiveness was reduced after addition of the myosin light chain kinase inhibitor ML-7 or the myosin II inhibitor blebbistatin in a5b1-high cells, but not in a5b1-low cells, suggesting that a5b1 integrins enhance cell invasion through enhanced generation of contractile forces.

BP 32.11 Thu 17:15 Poster B1

Increase of cell stiffness in single muscle cells from patients with primary desminopathies — •Navid Bonakdar[1], Philip Kollmannsberger[1], Rolf Schröder[2], and Ben Fabry[1] — [1]Center for Medical Physics and Technology, Biophysics Group, Dept. of Physics, University of Erlangen-Nuremberg, Erlangen, Germany — [2]Intitute of Neuropathology and Department of Neurology, University Hospital Erlangen, Germany

Desmin-related myopathies belong to the heterogenous group of distal-onset skeletal myopathies characterized by large accumulation of desmin (IFs) (Goebel et al. 1997), which compromises the ability of desmin to assemble into intermediate filaments (Sjoberg et al. 1999). Myofibrilar myopathies (MFMs) are histopathologically characterized by desmin-positive protein aggregates and myofibrillar degeneration and are caused by mutations in genes encoding for extramyofibrillar proteins. The disease usually develops in the second to third decade of life with signs of muscle weakness in the lower extremities and sometimes the heart. (Schröder et al., 2007). The precise molecular pathways and sequential steps that lead from an individual gene defect to progressive muscle damage are still unclear. (Schröder et al. 2009) Here we present the results of rheological measurements of myoblasts with and without desmin aggregation. Cell rheology is measured using FN-coated beads forced in a high-force Magnetic Tweezers setup. Stiffness of cells with desmin aggregation is markedly increased, indicating that desmin is directly involved with mechanical cell alteration that may contribute to the progression of MFMs.

BP 32.12 Thu 17:15 Poster B1

Tumor cell invasion as a random walk with density dependent diffusivity — •Claus Metzner, Julian Steinwachs, Franz Stadler, Martina Fellner, Claudia Mierke, Andreas Kronwald, Sebastian Probst, and Ben Fabry — Biophysics Group, Department of Physics, University of Erlangen, Germany

An important problem in cancer research is to understand the migration of tumor cells through connective tissue. We investigate the invasion of a layer of carcinoma cells into a 3D collagen gel and measure the temporal development of the spatial cell distribution. The distributions do not resemble normal particle diffusion into a half space. In particular, a strong dependence on initial cell density is indicative of collective effects. We show that all characteristic features are captured by a simple model: cells detect the presence of closeby neighbors, form clusters, and have a reduced diffusion constant in this clustered state. By optimizing only three parameters, the diffusion constants and the detection range, quantitative agreement is obtained between measured and Monte-Carlo-simulated invasion profiles.

BP 32.13 Thu 17:15 Poster B1

Phase Transitions in Embryonic Development: How P-Granules Segregate — Jöbin Gharakhani[1], •Clifford Brangwynne[1,2], Anthony Hyman[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute for Molecular Cell Biology and Genetics, Dresden, Germany

In the nematode C. elegans, germ cells and their precursors carry P-granules which are aggregates of proteins and RNA. P-granules are important in the specification of germ line cells. During the first cell division of the fertilized egg, P-granules are segregated towards the posterior side and are subsequently found in the posterior daughter cell. A fundamental question is to understand the mechanisms of segregation during asymmetric cell division. It has recently been shown that P-granules segregate by preferentially nucleating and subsequently growing on the posterior side of the cell, thereby effectively localizing the granular material. This preferential condensation can be explained by a gradient which decreases the saturation point of this phase transition along the anterior-posterior axis of the cell. Using a simulation describing nucleation, droplet growth, and fusion, we study

the P-granule segregation driven by a gradient of supersaturation in the cell.

BP 32.14 Thu 17:15 Poster B1

High-precision tracking of sperm swimming fine-structure provides strong test of resistive force theory — Benjamin M. Friedrich[1,3], Ingmar H. Riedel-Kruse[2,4], Jonathon Howard[2], and •Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute for Molecular Cell Biology and Genetics, Dresden, Germany — [3]Weizmann Institute of Science, Rehovot, Israel — [4]Department of Bioengineering, Stanford University, Stanford, USA

Sperm cells are propelled in a liquid by regular bending waves of their whip-like flagellum. The shape of the flagellar wave determines the path along which a sperm cells swims. We have tested a simple hydrodynamic theory of flagellar propulsion known as resistive force theory: We conducted high-precision measurements of the head and flagellum motions during circular swimming of bull spermatozoa near a surface. We found that the fine-structure of sperm swimming represented by the rapid wiggling of the sperm head around an averaged path is, to high accuracy, accounted for by resistive force theory and results from balancing forces and torques generated by the beating flagellum. We determined the ratio between the normal and tangential hydrodynamic friction coefficients of the flagellum, to be 1.81±0.07 (mean±s.d.). We also determined how the coarse grained curvature of the swimming path depends on the average curvature of the beat pattern. The observed ratio of these curvatures can be accounted for by resistive force theory. Hence, this theory accounts both for the fine-structure of sperm swimming as well as for the circular motion on larger scales.

BP 32.15 Thu 17:15 Poster B1

Theoretical and experimental studies of Protein Kinase C membrane translocation processes — •Martin Peglow[1], Mike Bonny[1], Heiko Rieger[1], Karsten Kruse[1], and Lars Kaestner[2] — [1]Theoretische Physik, Universität des Saarlandes, Campus, 66123 Saarbrücken — [2]Institut für Molekulare Zellbiologie, Universitätsklinikum des Saarlandes, 66421 Homburg

Protein Kinase C α (PKCα) is a versatile key for decoding the cellular calcium toolkit. Once activated by cytosolic Ca^{2+} ions PKCα translocates to the plasma membrane and creates local patterns with limited spatial spread ($< 4\mu$m), the so-called local translocation events (LTEs). Two populations of LTEs exist, namely short lived events with lifetimes of 500-1500 ms and long lasting events with duration up to 10 seconds, which markedly exceeds the duration of the underlying calcium signals [1]. If we incorporate a possible interaction between membrane bound PKCα in our stochastic three-dimensional reaction-diffusion model, we can explain both LTE populations. In addition to our computer simulations, we perform fluorescence resonance energy transfer (FRET) measurements to give evidence for our assumption of a so far unkown interaction in between membran bound PKCs molecules.

[1] Gregor Reither, Michael Schaefer, Peter Lipp, Journal of Cell Biology, 174, 521-533 (2006)

BP 32.16 Thu 17:15 Poster B1

Strain Dependent Cell Response to Optical Forces — •Tina Händler, Roland Stange, Anatol Fritsch, and Josef Käs — University of Leipzig, Germany

The optical stretcher is a device to investigate global mechanical behavior of single cells in suspension. Cells are trapped between two counter-propagating laser beams. By increasing the laser power and hence the momentum transferred to the cell surface, the cells are measurably deformed. Since the cytoskeleton, a dynamic polymer network inside the cell, is responsible for cellular mechanical properties, changes in the cytoskeletal proteins are reflected in the cell's response to the stress applied.

For small deformations and low stresses, most of the cells deform viscoelastically. At higher stresses, some cells seem to respond actively to the applied forces and show contractive behavior. This temporary decrease in relative deformation can be observed by using a linearly increasing laser power. Modifying motor proteins and microtubules with chemical agents allows a differentiated investigation of the observed phenomena. The aim of the presented work is to explore the role of cytoskeletal components in possibly stress-induced active behavior.

BP 32.17 Thu 17:15 Poster B1

Cellular force generation and transmission in 3T3 fibroblasts — •Florian Schlosser[1], Daisuke Mizuno[2], Florian Rehfeldt[1], and Christoph F. Schmidt[1] — [1]Drittes Physikalisches Institut, Georg-August-Universität Göttingen, Germany — [2]Organization for the Promotion of Advanced Research, Kyushu Univ., Fukuoka, Japan

Biological cells constantly communicate with their environment. Besides biochemical interactions, cells can also sense their mechanical micro-environment and external forces. Key players in the mechanosensing and -transduction processes are acto-myosin stress fibers that generate contractile forces.

To elucidate the mechanistic details of the physical interactions between cells and their surrounding, we use a dual optical trap to perform high-resolution measurements of cellular force fluctuations. Monitoring the displacement fluctuations of two fibronectin-coated beads attached to opposite sides of a cell and analyzing their correlated motions in conjunction with active probing of the cell with oscillating forces allows us to measure simultaneously the overall forces the cell generates and the fraction of that force transmitted to the environment. We present data of force fluctuations and cell stiffness of 3T3 fibroblasts obtained by such active and passive microrheology measurements. To distinguish non muscle myosin II - based activity from other effects, we used blebbistatin, a potent and specific inhibitor of non-muscle myosin II.

BP 32.18 Thu 17:15 Poster B1

Biomechanical Data Networks — •Tobias R. Kiessling, Kenechukwu D. Nnetu, Anatol Fritsch, Roland Stange, and Josef A. Käs — University of Leipzig, Institute of Experimental Physics I, Linnéstr. 5, 04103 Leipzig, Germany

The transition from benign tissue to malignant cancer is accompanied by various alterations of the cellular organization, amongst others of the cytoskeleton. This highly dynamic polymer network provides both, functional and mechanical stability to cells whereas small changes of the cytoskeletal composition are reflected in alterations of the mechanical properties of cells.

The Microfluidic Optical Cell Stretcher, built to monitor these cytoskeletal changes provides a fast and easy access to a range of physical parameters of thousands of cells. Methods derived from gene expression network analysis techniques will be discussed that help to reveal unbiased relations between measured physical properties and how these can be used to differentiate between benign and malignant cells without the need of any molecular marker.

BP 32.19 Thu 17:15 Poster B1

Quantification of hematopoietic stem cell and neutrophil chemotaxis using microstructured systems and ELISA — •Christina Leinweber[1], Rainer Saffrich[2], Anthony D. Ho[2], Nicole Niemeier[3], Katja Schmitz[3], Michael Grunze[1,3], and Axel Rosenhahn[1,3] — [1]Applied Physical Chemistry, University of Heidelberg — [2]Department of Medicine V, University of Heidelberg — [3]IFG/ITG, Karlsruhe Institute of Technology

The migration of hematopoietic stem cells (HSC) towards bone marrow, the so called homing process, plays an important role in modern leukemia therapy. HSC are supposed to be guided by a concentration gradient of chemokines which are expressed by marrow cells, the mesenchymal stromal cells (MSC). Therefore we investigate the chemotactic response and migration behavior of HSC using different in vitro chemotaxis assays with increasing intricacy, e.g. migration experiments in microwells, transwells and within microstructured systems. These chip systems allow studying single parameters, such as migration kinetics, thresholds, sensing sensitivity and swarm behaviour, by varying the geometry of the microchannel structures. In order to establish the methods, particularly the microstructures, we also used neutrophil granulocytes differentiated from HL-60 cell line as a model system. Additionally we performed ELISA experiments to analyze the expression of the chemokine SDF-1 by MSCs, as SDF-1 is already known to be involved in the signalling process and most likely controls HSC migration. We determined the SDF-1 concentration in dependence on expression time and on MSC culture media.

BP 32.20 Thu 17:15 Poster B1

A precise and rapid UV laser ablation system for developmental cell biology studies — •Felix Oswald and Stephan Grill — Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

We are presenting a state-of-the-art laser ablation system for use in cell biology studies. Diffraction-limited dissection of biological samples is

achieved by coupling a pulsed ultraviolet laser (355 nm) to a conventional inverted microscope equipped with a confocal imaging system. With this setup, we can thus perform photo and plasma-induced ablation in areas up to 100 μm^2 and at high rates (500 Hz) by directing the beam with a fast mirror scanning system. Ablation experiments of the myosin-actin cytoskeleton of *Caenorhabditis elegans* embryos demonstrates the versatility and power of such a nanoscalpel in probing the mechanical properties of cellular structures during development.

BP 32.21 Thu 17:15 Poster B1

4D-Tracking of pathogens by Digital In-line Holographic Microscopy — •Sebastian Weisse[1], Matthias Heydt[1], Niko Heddergott[2], Markus Engstler[2], Michael Grunze[1,3], and Axel Rosenhahn[1,4] — [1]APC, University of Heidelberg — [2]Zoology I ,University of Würzburg — [3]ITG, Karlsruhe Institute of Technology — [4]IFG, Karlsruhe Institute of Technology

Digital Holographic Microscopy (DHM) using the in-line geometry is based on the original idea of Gabor's 'new microscopic principle'. An interference pattern containing the three dimensional information of the object encoded in phase and amplitude is recorded. Using computers, real space information about the object can be restored from these holograms applying a reconstruction algorithm. We built a portable, temperature-controlled holographic microscope to study the motion patterns of pathogenic microorganisms such as the blood parasite Trypanosoma brucei, the causative agent of African sleeping sickness under physiological conditions. The directed self-propulsion of Trypanosomes in the bloodstream of a mammalian host is essential for the clearing of immunglobulins from the parasite's cell surface by hydrodynamic drag force. This mechanism is one of the parasite's strategies to evade the host's immune system and thus directly linked to pathogenesis. So far the motility studies on this uniflagellated microorganism have only been carried out using standard 2D microscopy techniques. In our system parasites were tracked at varying temperatures and viscosities with high spatial and temporal resolution and the obtained 3D motion patterns statistically analyzed.

BP 32.22 Thu 17:15 Poster B1

High Resolution Growth Cone Actin Dynamics — •Melanie Knorr[1], Timo Betz[2], Daniel Koch[3], and Josef Käs[1] — [1]University of Leipzig — [2]Institut Curie, Paris — [3]Georgetown University, Washington D.C.

Neuronal growth is one of the fundamental processes in brain developement and nerve regeneration. During growth, neuronal cells form long extensions, called neurites, which are guided toward their target sites by a motile structure at their tip, the so called growth cone. These growth cones are able to rearrange their cytoskeleton for directed growth, following very small guidance cues. Former research suggests amplification of these chemical signals via stochastic fluctuations of the leading edge of growth cones. Betz and Koch et al. already showed that the stochastic lamellipodium dynamics are determined by the interplay of actin polymerization, pushing the edge forward and molecular motor driven retrograde actin flow retracting the actin network. They identify switching of "on/off" states in actin polymerization as the main determinant of lamellipodial advancement. Further quantification of the suggested stochastic signal amplifiction, however, is limited by the spatial and temporal resolution of their imaging technique. Novel techniques and their realization are presented and discussed, able to detect the edge dynamics in higher temporal and spatial resolution.

BP 32.23 Thu 17:15 Poster B1

Vinculin regulates cell mechanical properties through src phosphorylation on its lipid anchor — •Nadine Lang, Gerold Diez, Wofgang Goldmann, and Ben Fabry — Biophysics Group, FAU Erlangen-Nürnberg, Germany

The focal adhesion protein vinculin links the actin cytoskeleton to integrin adhesion receptors.It has been reported that vinculin also binds to the lipid bilayer of the cell membrane.Vinculin with mutated or missing lipid binding regions leads to reduced focal adhesion turnover and decreased cell motility.We investigated whether this effect is directly caused by impaired lipid binding,or indirectly by mutations of residues on the lipid binding regions that are important for signaling.Vinculin has two lipid binding regions on its tail:one located on helix 3 has no phosphorylation sites,and another at the C-terminal(lipid anchor) which harbors a src-kinase regulated phosphorylation site at residue Y1065.Cells with mutations on helix 3 showed no change in stiffness (demonstrated by magnetic tweezer),in tractions(measured by traction microscopy)and in adhesion strength(determined by FN-coated bead detachment from the integrin receptor).In contrast,cells with missing lipid anchor or impaired lipid binding by mutating residues R1060 and K1061 showed strongly reduced stiffness,tractions and adhesion strength.Nearly identical behavior was observed if only the src phosphorylation site on the lipid anchor was mutated.These data show that lipid binding of vinculin's anchor is required for vinculin's mechanocoupling function, which in turn is regulated via src phosphorylation.Thus, vinculin is an important signaling protein in the FAC.

BP 32.24 Thu 17:15 Poster B1

Interaction between nanoparticles and living cells with force spectroscopy — •Sebastian Zünkeler, Daniel Wesner, Katja Tönsing, and Dario Anselmetti — Experimental Biophysics & Applied Nanoscience, Faculty of Physics, Bielefeld University

Nanotechnology is regarded as a key technology of the 21st century and nanotechnological systems are already used in many applications. However, the interaction between nanoparticles (NP) and living cells is not yet fully understood in the context of toxicology and need therefore additional characterization. To analyze these interactions with AFM force spectroscopy we have used an epoxide resin as adhesive for different metal oxide NP and attach aggregates which consist of primary particles to AFM-cantilevers. The characterization of the tip is possible with electron microscopy and the use of AFM and an inverse grid. We have shown that the used NP bind most likely unspecific to RLE-6TN rat lung cells. The number of rupture events increase with the contact time between tip and cell membrane and the measured rupture forces in the range of 50 pN depend mainly on micromechanical membrane properties.

BP 32.25 Thu 17:15 Poster B1

Collective organization and separation of multicellular systems — •Anatol Fritsch, Tobias Kiessling, Franziska Wetzel, Mareike Zink, and Josef Käs — University of Leipzig, Germany

For the spatial organization of tissue in multicellular organisms the mechanical properties of single cells and their environment are of great importance. In embryogenesis cells have to migrate to their future destinations and furthermore collectively separate from other cell groups. Biomedical studies indicate that these compartments of cells have sharp borders keeping even cancerous cells from migrating across. From a physical point of view this may be explained with differences in surface tension, migration or mechanical stiffness of the cells.

We study the mechanical properties of primary tumor cells of different tissues using optical surface forces on single cells as well as their adhesion forces. Primary cells from different compartments or cell types are labeled and mixed to form a multicellular tumor spheroid. Active demixing of the different cell types can lead to sharp boarders separating them, which is then correlated to the single cell data acquired in precedent studies.

BP 32.26 Thu 17:15 Poster B1

Structure and dynamics of stress fibers in 3T3 fibroblasts — •Constantin Spille, Til Driehorst, Florian Rehfeldt, and Christoph F. Schmidt — Drittes Physikalisches Institut, Georg-August-Universität Göttingen, Germany

Mechano-sensing and force transduction play an essential role in many cellular processes but the microscopic mechanisms are not yet understood. Acto-myosin stress fibers are key players in the physical response to the mechanical micro-environment as demonstrated in recent studies of cells spreading on elastic substrates. Stress fibers are composite structures of actin bundles, cross-linked by alpha-actinin, and mini-filaments of non muscle myosin II (NMM II) that generate contractile forces.

We here present data, obtained by confocal microscopy, on the structure of stress fibers in 3T3 fibroblasts adhering to elastic substrates of varying stiffness. Staining fixed cells at different time points for actin, NMM IIa, and alpha-actinin, has allowed us to quantitatively analyze the influence of the mechanical properties of the surrounding on the cell's cytoskeleton and on the architecture of stress fibers.

BP 32.27 Thu 17:15 Poster B1

Mechanical characterization of primary cilia of epithelial cells — •Christopher Battle and Christoph F. Schmidt — Drittes Physikalisches Institut, Georg-August Universitaet, Goettingen, Germany

Recent studies have shown that the primary cilium, long thought to be a vestigial cellular appendage with no function, has remarkable sensory

abilities. Of particular interest, from both a biophysical and medical standpoint, are the primary cilia in kidney epithelial cells, which have been demonstrated to act as tiny flow sensors. The cilia are lined with mechanosensitive TRP channels (PC2), which allow the influx of cations into the cell in response to mechanical stimuli. We explore the mechanical response of this system using fluorescence microscopy and optical trapping techniques.

BP 32.28 Thu 17:15 Poster B1

Confined Intermediate Filament Fluctuations in Live Cells — •Jannick Langfahl-Klabes[1], Jens Nolting[1], Alexander Egner[2], and Sarah Köster[1] — [1]Courant Research Centre Nano-Spectroscopy and X-Ray Imaging, University of Göttingen, Germany — [2]Max Planck Institute for Biophysical Chemistry, Göttingen, Germany

The cytoskeleton, which provides mechanical strength for the cell, contains three different types of fibrous proteins. Besides actin and microtubules intermediate filaments (IFs) play an important role. IFs are extremely flexible biopolymers that can be stretched to several times their initial length. The key to these large deformations is their hierarchical structure, which facilitates cascaded deformation mechanisms at different levels of strain. The filamentous structures in live cells are by no means static but undergo excessive fluctuations and show dynamics on many different time scales. We investigate keratin intermediate filament networks which are believed to play a key role in cell mechanics. To this end we carry out time-lapse fluorescent live cell imaging experiments on genetically enhanced carcinoma cells. These model cells express fluorescent keratin which forms thick cytoplasmic bundles. We perform fluctuation analyses based on the worm-like-chain model to investigate the influence of thermal versus active motion and retrieve mechanical properties like persistence length and bending rigidity. Our results show that keratin bundles are strongly confined within the surrounding network. This observation is further confirmed by a structural analysis using high-resolution STED microscopy.

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Influence of Microfluidic Shear on Keratin Networks in Live Cells — •Jens Nolting, Jannick Langfahl-Klabes, and Sarah Köster — Courant Research Centre Nano-Spectroscopy and X-Ray Imaging, University of Göttingen, Germany

Intermediate filaments (IFs) are a major component of the eukaryotic cytoskeleton along with microtubules and microfilaments. IFs show a hierarchical build-up which distinguishes them from other cytoskeletal filaments and leads to a pronounced flexibility. Here, we present a study of keratin intermediate filament networks in live cells which are believed to play a key role in cell mechanics, in particular with regard to external forces. We expose cells expressing fluorescent keratin proteins to shear forces applied by microfluidic methods and investigate the response of the keratin cytoskeleton. This approach enables us to apply well-defined flow fields due to controlled external parameters and variable microchannel layouts. Moreover, the shear flow can be established such that it acts on one individual cell or on groups of cells. In combination with finite element method simulations of flow conditions and fluid-cell-interactions and experimental flow-field analyses these experiments provide important steps towards an understanding of the rheological properties of whole cells.

BP 32.30 Thu 17:15 Poster B1

Modelling the Polymorphism of Bacterial Flagella — •Christoph Speier, Reinhard Vogel, and Holger Stark — Institut für Theoretische Physik, TU Berlin

Bacteria such as *E.coli* propel themselves using a bundle of long helical tails, known as flagella. The main part of the flagellum is a cylindrical structure made from 11 protofilaments that are assembled from thousands of copies of the protein flagellin. This subunit can assume two different states (R and L) with different RR and LL distances. Proteins of the same state are stacked onto each other to form one protofilament. The flagellum can adapt different helical forms (polymorphism). While flagella, in which all proteins are in the same state, form straight tails, they exhibit a helical structure when protofilaments of both R and L type occur. Transitions between different forms of the flagellum can be induced by changing the salt-concentration or the pH value of the solvent and by applying external torques.

The well established Calladine model explains the different possible helical states of the flagellum but provides no understanding why it conventionally assumes the so-called normal state. Refining an existing model, we consider the flagellin protein as a bistable rigid-body unit with state-dependent bonds to neighboring units. Whereas the outer bonds determine the helical form of the filament, the inner bonds are responsible for its structural stability. With our model we can verify that the normal state is only stable when the rigid-body unit assumes an elongated shape in accordance with the real form of flagellin.

BP 32.31 Thu 17:15 Poster B1

Hopf Bifurcation in Rotating Bacterial Flagella — •Reinhard Vogel and Holger Stark — TU Berlin

Many types of bacteria swim by rotating a bundle of helical filaments also called flagella. Each filament is driven by a rotatory motor. When its sense of rotation is reversed, the flagellum leaves the bundle and undergoes a sequence of configurations characterized by their pitch, radius and helicity (polymorphism). Finally the flagellum assumes its original form and returns into the bundle.

The flagellum of bacteria such as *E. coli* and *Salmonella* consists of three parts; the rotary motor embedded in the cell membrane, a short proximal hook that couples the motor to the third part, the long helical filament. The hook has a well regulated length of $0.055\mu m$ and a diameter of around $0.02\mu m$. The filament is up to 20 μm long and like the hook about $0.02\mu m$ in diameter. It is relatively stiff but can switch between distinct polymorphic forms.

In this contribution, we demonstrate how the hook transmitting the torque of the motor to the filament can be modeled. We then investigate the shape of the flexibel helical filament when the motor torque is applied. For small torques acting such that the cell body is pushed forward, the helix axis is approximatly parallel to the torque and the filament is only slightly deformed. The thrust force assumes a stationary value. However, when the torque is increased, the filament starts to bend which is visible through a Hopf bifurcation in the thrust force. We discuss the importance of this bifurcation for the bundle formation and for the transitions between different polymorphic configurations.

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Calcium Signaling upon mechanical stimulus in the Optical Stretcher — •Markus Gyger and Josef Käs — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik I, Linnéstraße 5, 04103 Leipzig, Germany

Under physiological conditions many cells must react to mechanical stimuli. Calcium is one of the most important second messengers and is involved in most of the known mechano-activated cell responses. There are indications that during tumorgenesis the calcium signaling of a cell changes most likely leading to suppression of apoptosis and altered gene expression. The calcium influx can be made visible by appropriate fluorescent dyes, also chelating agents, quenching internal calcium signals as well as external calcium, are available. This provides a broad range of tools for the investigation of effects of calcium on the response of the cell to an external stimulus. The Optical Stretcher is a tool to probe global mechanical behavior of single cells in suspension. Cells are trapped by two anti-parallel laser beams. By increasing the laser power the momentum transferred to the cell surface causes visible deformations. Some cells, especially cancer cells, seem to respond actively to these deformations sometimes even resulting in a contraction of the cell relative to its initial, undeformed state counteracting the applied force. This raises interesting questions regarding the mechanisms by which cells register and respond to the applied forces. The aim of the presented work is to investigate the dependence of calcium influx on the forces applied to the cell surface in order to gain insight into the mechanisms of active responses to stretching.

BP 32.33 Thu 17:15 Poster B1

Continuous versus Boolean dynamics on simple networks — •Eva Gehrmann and Barbara Drossel — Institut für Festkörperphysik, TU Darmstadt

We compare Boolean dynamics with continuous dynamics on simple network structures, which can be viewed as relevant modules of regulatory networks. The knowledge of regulatory and signaling processes in living cells is often only of qualitative nature, which gave rise to the description as Boolean networks, where the state of each gene is either "on" or "off". In recent years, experiments yielded more quantitative data for regulatory processes and their kinetic parameters. This leads back to the effort to describe processes in the cell with more realistic continuous models, which may give rise to dynamical phenomena that are not accessible with Boolean networks. Continuous models implement the switch-like dynamics of genes by using the sigmoidal Hill function and by using ordinary differential equations to evaluate the time course of the gene expression patterns. We use simple network

components and a systematic rule for replacing Boolean functions with continuous functions in order to identify the main differences between the dynamical behavior and the attractor patterns of Boolean and continuous models.

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Chemotaxis model for bacteria with twitching motility — •Johannes Taktikos, Vasily Zaburdaev, and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, D-10623 Berlin, Germany

We construct a model to study the characteristic motion of bacteria on a surface. Once bacteria, such as *Pseudomonas aeruginosa* or *Neisseria gonorrhoeae*, reach a surface they lose their helical flagella and instead use filaments, so-called type IV pili, to move forward. The resulting twitching motility represents an important and necessary mechanism that many types of bacteria use to form biofilms.

The main ingredient in our model is chemotaxis. This describes the bacterium's ability to orient its velocity direction along the gradient of the chemotactic field which is given by the concentration of a certain chemical. In our case, the chemical is produced by the bacteria themselves to attract each other and obeys a simple reaction diffusion equation. In a first approach, we neglect fluctuations in the absolute value of a bacterium's velocity and formulate a Langevin equation for the direction of the velocity. It consists of a deterministic part due to chemotaxis and a stochastic term representing both thermal and other sources of noise. The stochastic term alone would lead to rotational diffusion. Using computer simulations, we analyze possible time-dependent structures of bacterial paths and classify different patterns of collective motion.

BP 32.35 Thu 17:15 Poster B1

Contact-controlled amoeboid motility in microstructures induces topophoresis — •Carolin Leonhardt, Delphine Arcizet, Sofia Capito, Simon Youssef, Susanne Rappl, Joachim O. Rädler, and Doris Heinrich — Center for Nanoscience, Ludwig-Maximilians-Universität, München

Amoeboid motility is crucial for functionality in many organisms. On a flat and homogeneous substrate, it is generally described as a random walk: Fast and directed migration alternates stochastically with phases of local random probing. To investigate the effect of surface topography on this search strategy, which is a key to understand the interplay between migration dynamics and cellsubstrate interactions, we combined high resolution motion analysis and defined microstructured environments. We found that cells of the model organism Dictyostelium discoideum preferentially localise in contact with micropillars and that directed cell migration is biased towards the density gradient within arrays of varying pillar density: the cells undergo topophoresis. Our findings are consistent with a stabilisation of random protrusions that is induced by surface contact. This contact-reinforced motility may enable amoeboid cells to efficiently migrate in their natural habitat while searching for food. This effect could enable us to trap cells by topographical means only.

BP 32.36 Thu 17:15 Poster B1

Instabilities of Active Polar Gels in a Taylor-Couette Geometry — •Marc Neef and Karsten Kruse — Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken

In many physiologically relevant situations, the dynamics of the cytoskeleton or of tissues in developing organisms occur in a confined geometry. From a physical point of view, both systems, the cytoskeleton of eukaryotic cells as well as ensembles of crawling cells, fall into the class of active polar gels. The generic behavior of such systems is captured by hydrodynamic equations that account for activity, stress generating processes and polar order. We employ the hydrodynamic theory to study instabilities of active polar gels confined to the space between two coaxial rotating cylinders, i.e., a Taylor-Couette geometry. In particular, we analyse the stability of states with orthoradial polarity and find that the system's activity together with its polarity can generate instabilities even in situations when neither of the cylinders rotates.

BP 32.37 Thu 17:15 Poster B1

Modelling protein accumulation at DNA damage sites — •Daniel Löb and Barbara Drossel — Technische Universität Darmstadt, Institut für Festkörperphysik

Cells react to DNA damage by rapidly accumulating and chemically modifying repair and signalling proteins. As a result of this, zones of massively increased repair protein concentrations, called foci, appear centered around the damage sites. The reaction processes that govern the formation of these foci are characterized by ongoing association and dissociation of proteins at specific rates.

We explore the protein accumulation dynamics using analytical calculations as well as computer simulations based on ordinary differential equations and stochastic methods. It is a focus of our work to investigate the possibility of multistability and switching between different pathways.

We also discuss the implications this has on our understanding of the single-strand break repair mechanism Base Excision Repair (BER).

BP 32.38 Thu 17:15 Poster B1

Influence of subsurface composition on the adhesion of bacteria and the adsorption of proteins — •Peter Loskill, Yvonne Schmitt, Hendrik Hähl, and Karin Jacobs — Saarland University, 66123 Saarbrücken, Germany

Biofilms are of special importance in various fields of the everyday life. Their initial formation is composed of two crucial steps: the adsorption of proteins and the adhesion of bacteria. These are complicated processes that depend on many factors.

So far, most studies focused on surface chemistry, hydrophobicity and surface roughness - factors which influence mainly the short range interactions.

Our studies concentrate on the impact of long range interactions, in particular van der Waals forces, which can be tuned by the use of tailored substrates. To characterize the processes, we follow two pathways: One way is to characterize protein adsorption on a fundamental level via ellipsometry. Another is to directly probe bacterial adhesion by AFM - force spectroscopy. As model systems we use *Staphylococcus aureus* bacteria and proteins like amylase, lysozyme and bovine serum albumin. The results of our experiments show that protein adsorption kinetics as well as bacterial adhesion are dependent on the subsurface composition of the substrate [1,2]. Hence it is of great importance for the design of anti-adhesive surfaces to consider not only the lateral but also the vertical composition of the substrate.

[1] A. Quinn et al., *Europhysics Lett.* 81 (2008) 56003
[2] M. Bellion et al., *J. Phys.: Condens. Matter* 20 (2008) 404226

BP 32.39 Thu 17:15 Poster B1

Bacterial probes with defined contact area for force spectroscopy — •Sebastian Hümbert, Peter Loskill, and Karin Jacobs — Saarland University, 66123 Saarbrücken, Germany

Bacterial adhesion is a key factor in disease pathogenesis. Thus it is essential to understand the interaction of microorganisms with biological and artificial surfaces. A promising tool is to perform force-spectroscopy using an atomic force microscope (AFM) with the bacteria themselves as AFM probes. The aim of the studies presented is to create functionalized bacterial probes with a defined contact area to perform reliable force/distance measurements on various surfaces. Fundamental parameters are the tip geometry and the way the bacteria are 'glued' to the AFM tip. The adhesion protein must not alter the bacterial membrane, yet still has to be strong enough to hold the bacteria firmly onto the tip during the force/distance measurements. We show results for binding bacteria to the cantilever via charge effects, via covalent binding and via specific binding using different cantilever coatings. Our primary aim is to study the influence of the tip geometry and we present the outcome of experiments with single bacteria as probes and with bacteria-coated colloidal probes.

BP 32.40 Thu 17:15 Poster B1

A dynamic model for the morphogenesis of the Golgi apparatus — •Jens Kühnle[1,2], Julian C. Shillcock[2], Ole G. Mouritsen[2], and Matthias Weiss[1] — [1]German Cancer Research Center, Heidelberg — [2]Center of Membrane Physics, University of Southern Denmark

The dynamic compartmentalization of eukaryotic cells is a fascinating phenomenon that is far from being understood. A prominent example for this challenge is the Golgi pparatus, the central hub for protein sorting and lipid metabolism in the secretory pathway. Despite major advances in elucidating its molecular biology, the fundamental question of how the morphogenesis of this organelle is organized on a system's level has remained elusive. Here, we have formulated a coarse-grained computational model that captures key features of the dynamic morphogenesis of a Golgi apparatus. In particular, our model relates the experimentally observed Golgi phenotypes, the typical turnover times,

as well as the size and number of cisternae to three basic, experimentally accessible quantities: the rates for material influx from the endoplasmic reticulum, the anterograde and the retrograde transport rates. Based on these results, we elucidate which factors are crucial for the structure formation of the Golgi apparatus. Moreover, we propose which molecular factors should be mutated to alter the organelle's phenotype and dynamics.

BP 32.41 Thu 17:15 Poster B1

Measuring Cytoskeletal Orientation Distributions of Large Cell Populations by Digital Image Processing — •Norbert Kirchgessner, Uta Zedler, Nico Hampe, Wolfgang Rubner, Bernd Hoffmann, and Rudolf Merkel — Institute of Bio- and Nanosystems 4: Biomechanics, Forschungszentrum Jülich GmbH, 52425 Jülich

Cell adhesion is vital for most cell types and supported by various proteins forming defined adhesion structures. These complex structures bind to both the cellular environment and to intracellular actin filaments. This direct interaction enables cells to actively sense and to respond to varying mechanical conditions. Cyclic stretch is such a mechanical signal with thereby induced cellular reorientations. Cell orientation given by the major axis of the cell shape is distinguished from cytoskeletal orientation defined by stress fibers. However, exact whole cell and cytoskeletal reorientation angles are difficult to determine.

Our approach applied the gradient based structure tensor method to bandpass filtered fluorescence microscopy data. In combination with a segmentation step this yielded accurate histograms of cytoskeletal orientations for individual cells. Subsequently, we obtained the predominant cytoskeletal orientation of each cell and intracellular orientation variations of stress fibers. Cellular orientations were determined as the major direction of the ellipse with equal normalized second central moment as the segmentation results for each cell. Application of these algorithms to large numbers of cells (n>200) yielded results with high statistical relevance.

BP 32.42 Thu 17:15 Poster B1

Construction and dynamics of a bistable genetic switch in E. coli — •Christoph Klingner, Susann Berthold, Ralf Jungmann, Eike Friedrichs, and Friedrich C. Simmel — Lehrstuhl für Bioelektronik, E14 TU München, James Franck Str., 85748 Garching, Germany

Standard genetic engineering tools can be utilized for the development of artificial gene regulatory circuits. Synthetic gene circuits can be used to "reprogram" bacterial cells in order to achieve artificial functions and behavior. In addition, they may prove useful for the elucidation of gene regulatory dynamics within a controlled setting. Among the simplest possible regulatory circuits, bistable or multistable genetic systems are of particular interest, as they may be utilized to switch between several distinct "states" of a cell. Furthermore, switching mechanisms are a key ingredient of more complex genetic programs.
We here present the construction of a simple genetic switch based on the LacI and pTetR promoters, which can be switched chemically between two possible states. The regulatory dynamics of each of the two subsystems are investigated in the bacterium *Escherichia coli* in terms of stability, reproducibility and velocity while toggling with the inducers isopropyl thiogalactoside (IPTG) and anhydrotetracycline (aTc). The inhibition as well as positive auto-regulation of gene expression are studied and compared to model simulations.

BP 32.43 Thu 17:15 Poster B1

Magnetic Resonance Imaging (MRI) of tumor cell migration in animals — •Christian Weis[1], Ben Fabry[1], and Andreas Hess[2] — [1]Biophysics Group, FAU Erlangen-Nürnberg — [2]Lehrstuhl für Pharmakologie und Toxikologie, FAU Erlangen-Nürnberg

The process of metastasis formation involves the migration and 3-D invasion of tumor cells from a primary tumor to distant sites. Our aim was to monitor the dynamics of cell migration and invasion in animals over prolonged time periods using MRI. Human breast carcinoma cells were labeled with superparamagnetic γFe2O3 iron oxide nanoparticles. Particles were stabilized and biofunctionalized with poly-l-lysine. Approximately 10,000 cells were incubated with 1 ug of particles for 24 h. Particles are readily taken up by cancer cells and stored in intracellular clusters. During cell division, the nanoparticle clusters are divided and split between daughter cells. Nanoparticles remain stable for at least 3 weeks. In-vitro collagen gel assays show that there is no difference between the spreading or invasion behavior of tumor cells with and without nanoparticles. MRI imaging (conventional multi-spin sequences with a repetition time of 1000 ms and 8 echo times between 11 and 165 ms) of cells suspended in 2% agar gave a detection limit of the R2 relaxation rate of 20 uM Fe2O3, equivalent to 70 cells/mm2. The minimal detection volume of tumor cells in agar was 25 ul. Detection limit and minimal volume were verified by injecting labeled cancer cells in dead mice. To achieve high sensitivity in mice, however, a slice thickness of less than 250 um was necessary, which leads to whole-body scans with physiologically unacceptable duration (> 4h).

BP 32.44 Thu 17:15 Poster B1

Nonlinear Cell Mechanics Is Plastic Mechanics — Lars Wolff, •Andrea Kramer, and Klaus Kroy — Institut f. Theoretische Physik, Universität Leipzig

Recent investigations of the dynamical linear and nonlinear mechanical properties of single living cells have identified (at least) three major universal patterns of cell rheology: (i) power-law rheology, (ii) viscoelastic stiffening, and (iii) inelastic softening or "fluidization". We present a polymer-physics based minimal model that robustly reproduces all of these features and suggests their close mutual interdependence. In particular, the supposedly antagonistic effects of viscoelastic stiffening and fluidization are predicted to actually reinforce each other and the structural damping. The highly redundant nonlinear dynamical shear response of living cells is traced back to inanimate material properties shared by much simpler in vitro models of the cytoskeleton, notably by pure F-actin solutions, which has so far been experimentally validated only for (i) & (ii). According to the model, the core mechanism responsible for the mechanics of living cells and tissues is comprised by a small set of equations coupling semiflexible polymer dynamics as described by the glassy wormlike chain model with "bond"-kinetics in the highly degenerate free energy landscape of an "Arrhenius gel". The good quantitative agreement of model predictions for viscoelastic and inelastic protocols with experimental data from both in vitro model systems and living cells suggests intriguing new directions for future experiments aiming to relate microscopic structural parameters with the mechanical response.

BP 32.45 Thu 17:15 Poster B1

Mechanisms of Parasitic Cell Motility in Blood Flow and Possible Impact on Host Infection — •Sravanti Uppaluri[1], Eric Stellamanns[1], Niko Heddergott[2], Stephan Herminghaus[1], Markus Engstler[2], and Thomas Pfohl[1,3] — [1]Max Planck Institute for Dynamics and Self Organization, Göttingen — [2]Biocenter, University of Würzburg — [3]Chemistry Department, University of Basel

African trypanosomes, parasites responsible for devastating disease in sub-Saharan Africa, are found in the mammalian bloodstream and penetrate the central nervous system during late stages of African Sleeping Sickness. Trypanosomes are able to make their way past the tightly protected blood brain barrier despite significantly high blood flow velocities in vessels around the brain. We find that the parasite is able to swim closer to vessel walls with increasing blood flow velocities. Typical vessels have a cell free layer near the channel walls, we mimic this phenomenon using microfluidic techniques and investigate the trypanosome's ability to make turns at relatively high flow velocities and invade through confining gaps. Gradient based microfluidics is exploited to test if the turning frequency is enhanced by chemical attractants. Lastly, we find that cell orientation is velocity dependent. Together our results point to strong hydrodynamical effects on swimming behavior of trypanosomes which may play an important role in different stages of infection.

BP 32.46 Thu 17:15 Poster B1

Quantitative temperature analysis by micro-thermo capillaries for biological systems — •Michael Stührenberg[1], Rene Heimbuch[1], Miriam Giesguth[2], Karl-Josef Dietz[2], Simone Herth[1], and Günter Reiss[1] — [1]Fakultät für Physik, Universität Bielefeld — [2]Fakultät für Biologie, Universität Bielefeld

Thermocouples based on the Seebeck effect between two metals are widely used for various applications. However, these thermocouples usually consist of wires of hundreds of nanometer thickness measuring the temperature in large objects and voluminous bulk phases. In a new setup, the two metals for the thermocouple are sputtered onto a glass micro capillary with an outer diameter of about 450 nm leading to very small contact and measurement areas. These thermo capillaries can be used in a micro manipulation system to measure the temperature in small tissues, single cells, or other biological objects,

e.g. leaf epidermis and trichomes. This poster reports the fabrication of micro-thermo capillaries and demonstrates its calibration and use for quantitative measurements.

BP 32.47 Thu 17:15 Poster B1

Local quantitative temperature measurements on silicon nitride membranes for biological applications — •Maksym Koch[1], Nadine Ewers[1], Carsten Budke[2], Britta Riechers[2], Thomas Koop[2], Simone Herth[1], and Günter Reiss[1] — [1]Fakultät für Physik, Universität Bielefeld — [2]Fakultät für Chemie, Universität Bielefeld

Thermocouples based on the Seebeck effect between two metals are widely used for various applications. However, these thermocouples usually consist of wires hundreds of nanometer thick measuring the temperature in large objects and voluminous bulk phases. In order to determine local temperatures, e.g., in single cells, thermocouples can be sputtered through special masks on top of a silicon nitride membrane. These membranes are only 50 or 100 nm thick and avoid extensive heat dissipation necessary for a quantitative analysis. Local quantitative temperature measurements were performed with Pd/Cr and Pd/NiCr with Seebeck coefficients of 27 uV/K and 35 uV/K, respectively, using various types of heating processes.

BP 32.48 Thu 17:15 Poster B1

Dynamics of cell shape on micropatterned substrates — •Jerome Soine[1], Achim Besser[1,2], and Ulrich Schwarz[1,3] — [1]Karlsruhe Institute of Technology, Theoretical Biophysics Group — [2]Harvard Medical School, MA, USA — [3]University of Heidelberg, Institute for Theoretical Physics

Free edges of adherent cells often adopt the shape of inward directed circular arcs. Combining experiments with cells on micropatterned substrates, quantitative image processing and modeling, recently it has been shown that the values for the arc radii can be explained by the interplay between tension in the cell envelope and elastic strain along the cell periphery (Bischofs et al., Biophysical Journal 95: 3488, 2008). Here we extend this model to predict the dynamics of shape changes on micropatterned substrates. The free edge of a cell between two adhesion sites is modeled as a actively contracting visco-elastic beam. Intrinsic isotropic surface tension pulls in the edge and leads to the circular arc shape. Inhibition of actin polymerization or myosin II motor activity leads to changes in arc radius which can be predicted by our model. Special focus is given to the effect of positive feedback loops involving signaling through the small Rho-GTPases.

BP 32.49 Thu 17:15 Poster B1

Cells on different substrates. An investigation with AFM and optical microsopy. — •Daniele Martini[1], Michael Beil[2], Othmar Marti[1], and Thomas Schimmel[3,4] — [1]Institute of exp. physics, Ulm University — [2]Institute of internal medicine I, Ulm University Hospital — [3]Forschungszentrum Karlsruhe — [4]Karlsruhe University

The main task of epithelial cells is to form a physical barrier, which is characterized by the properties of the cytoskeleton and cell-cell contacts. The principal aim of the first part of this project is to modulate the structure of these macromolecular complexes, optimizing the mechanical properties of the cells by a spatially hierarchically ordered and t-variable nanostructured culture substrate . Thus, at first, we have to investigate and control the growing and arrangement of these cells on different surfaces and, later, to define and influence the subcellular structure with chemically nanostructured culture substrates. In this poster we show AFM and optical microscopy experiments on adherent cells on different substrates. We discuss the influence of the substrate on cell morphology and on AFM images.