BP 30: Posters: Physics of Cells

Time: Thursday 17:15–20:00 Location: P3

BP 30.1 Thu 17:15 P3

Platelets on Micropatterned Surfaces — •Rabea Sandmann, Sarah Henriques G. Schwarz, and Sarah Köster — Courant Research Centre Nano-Spectroscopy and X-Ray Imaging, University of Göttingen, Germany

Stress fiber formation - the process of force generation in cells - depends on the substrate: Blood platelets on glass (50-90 GPa) show distinct stress fibers, which is not the case for soft polyacrylamid substrates (19 kPa). Platelets are essential for blood clotting and wound healing. Malfunctional platelets are the origin of many diseases like artherothrombosis. Despite of their important function in mammals, the composition of platelets is simple as they lack a nucleus. This renders them a convenient modell system to study mechanosensing and mechanotransduction of cells. During the activation process (part of blood clotting) the platelets' contractile cytoskeleton exerts forces upon the environment. However, the mechanisms of force generation are still unclear. In order to investigate the influence of substrate topology and chemistry on stress fiber generation in platelets, we structure polydimethylsiloxane substrates with patterns ranging from $0.5\,\mu m$ to $2.5\,\mu m$ both topologically and chemically and stain both stress fibers and focal adhesions at certain time points of activation.

BP 30.2 Thu 17:15 P3

Influence of Confinement on Keratin Bundles in Live Cells — •Jannick Langfahl-Klabes, Britta Weinhausen, Jens Nolting, and Sarah Köster — Courant Research Centre Nano-Spectroscopy and X-Ray Imaging, University of Göttingen

The major components of the eukaryotic cytoskeleton are actin filaments, microtubules and intermediate filaments (IFs). An abundant representative of the IF family is keratin, which can be found in large quantities in epithelial cells and is believed to play a key role in cell mechanics by maintaining cell shape and providing mechanical strength and stability against external forces. We carry out buckling experiments on cytoplasmic keratin bundles to investigate their mechanical properties and draw conclusions about the internal structure. The surrounding cytoskeletal (actin) network has a major influence on the bundles' buckling behavior via lateral reinforcement. Constraints imposed by the embedding network are also found in further analyses of time-lapse live cell imaging experiments. Our studies show that keratin bundles are strongly confined and perform restricted fluctuations inside a tube-like space. We use the results to estimate the internal structure of the keratin bundles and the influence of the surrounding network on the buckling behavior.

BP 30.3 Thu 17:15 P3

Microfluidic shear on keratin networks in live cells — •Jens-Friedrich Nolting, Jannick Langfahl-Klabes, and Sarah Köster — Courant Research Centre Nano-Spectroscopy and X-Ray Imaging, University of Göttingen, Germany

Intermediate filaments are a major component of the eukaryotic cytoskeleton along with microtubules and microfilaments. They play a key role in cell mechanics, providing cells with compliance to small deformations and reinforcing them when large stresses are applied. Here, we present a study of fluorescent keratin intermediate filament networks in live cells with respect to their behavior in the presence of external forces. We expose the cells to specified shear forces applied by microfluidic methods and investigate the response of the keratin network *in situ*. We accomplish a description of the full shear stress distribution acting on the cell using finite element method simulations of the flow conditions. This investigation shows that the shear flow does not lead to a noticeable deformation of the cells but apparently interacts with the cells' interior in an indirect way by inducing changes of internal processes. We find a considerable stiffening of the keratin bundle motion with the establishment and further increase of the shear flow. The dynamics change from a free and relatively independent "wobble"-motion to a restricted one, reminiscent of rigid rods.

BP 30.4 Thu 17:15 P3

Force Generation in Contractile Cells — •Sarah Schwarz G. Henriques[1], Hansjörg Schwertz[2], Alexander Strate[3], and Sarah Köster[1] — [1]CRC Physics, University of Göttingen, Germany — [2]Division of Vascular Surgery, University of Utah, USA — [3]Transfusion Department, University Clinic of Göttingen, Germany

Contraction at the cellular level is vital for living organisms. A most prominent type of contractile cells are heart muscle cells, a less well known example are blood platelets. Blood platelets are responsible for clot formation in mammals. They activate at damaged blood vessel sites by changing their shape, interlinking with each other and contracting to build a compact blood clot. Apart from being of great medical importance, blood platelets represent an ideal model system for studies of cellular contraction for two main reasons: They are simple being anucleate and their activation, which occurs within minutes, can be triggered and synchronized by the addition of thrombin. In our experiments we look at force generation at the level of single cells during platelet contraction. To this end, we use traction force microscopy which enables time-resolved measurements of force fields generated by isolated cells. Furthermore, we fix cells at different activation stages and stain both vinculin and actin in order to map focal adhesion sites and describe cytoskeletal reorganization steps. In combining both traction force microscopy and fluorescence imaging we can resolve traction force maps for single cells and simultaneously access information about force generating mechanisms in the cytoskeleton. Finally, we gather our experimental findings into a mechanical model for cellular contraction.

BP 30.5 Thu 17:15 P3

Cells on different substrates. An investigation with AFM and optical microscopy. — •Daniele Martini[1], Michael Beil[2], Thomas Schimmel[3,4], and Othmar Marti[1] — [1]Department of Experimental Physics, Ulm University — [2]Department of Internal Medicine I, Ulm University Hospital — [3]Forschungszentrum Karlsruhe — [4]Karlsruhe University

In this poster we discuss the influence of the substrate nanostructure on mechanical properties and motility of the cells.

The chemical and physical properties of the substrate can influence the cell motility and the mechanics and arrangement of the cytoskeleton. Nanopatterns of adhesion islands can be produced with lithography: in this way the mechanisms governing the determination of cell shape in response to external adhesive conditions can be analyzed. Changes in these characteristics can be observed measuring the stiffness of the cells with the AFM, making an indentation of a few hundreds nanometers. We estimate the stiffness applying the Hertz model to the obtained Force-Distance curve. Moreover, cell motility is also modulated by the substrate. In particular, we observed that cells cultivated on gold moves twice as fast as those on PS. Cells on aluminum move three times faster then those on PS.

BP 30.6 Thu 17:15 P3

The network of the RNA-binding protein AtGRP7, a component of a molecular slave oscillator in *A. thaliana* — •Christoph Schmal[1,3], Dorothee Staiger[2], and Peter Reimann[1] — [1]Theorie der Kondensierten Materie, Fakultät für Physik, Universität Bielefeld — [2]Molekulare Zellphysiologie, Fakultät für Biologie, Universität Bielefeld — [3]Bioinformatics of Signaling Networks, Center for Biotechnology, Universität Bielefeld

The AtGRP7 autoregulatory circuit is the first identified molecular "slave" oscillator that is coupled to the circadian ("master") oscillator of *Arabidopsis thaliana*. The AtGRP7 protein regulates the accumulation of its own mRNA at the posttranscriptional level via alternative splicing. It was recently shown that there is also a cross regulation with the AtGRP8 autoregulatory circuit. We model the system composed of these autoregulatory circuits interconnected with the "master" oscillator via an ordinary differential equation approach. As for many biological systems the parameters of these equations are barely known. We define a cost function that quantifies the overlap between our model and key experimental features. A search in parameter space evaluates if our proposed model fits with the given experimental data.

BP 30.7 Thu 17:15 P3

Manipulation of magnetic particles in living cells — •Haleh Ebrahimian — Bielefeld University ,Thin Films and Physics of Nanostructures , Bielefeld,Germany

In recent years, the so called Lab-on-the-chip system was developed and miniaturized for hand held applications. This system can also be

extended for the analysis of heat stress or signaling pathways by the manipulation of magnetic particles in living cells. For the manipulation of particles inside cells, three different steps are required:

1.Moving of particles by magnetic forces outside of cells. The manipulation had been done by magnetic forces which was generated by conducting lines applying 1.2 V.

2.Injection of particles into cells 1um diameter magnetic particles were injected into living cells of a fungus (*Mucor mucedo*),a protoplast of Cress (*Arabidopsis thaliana*), and a epidermis protoplast of barley (*Hordeum vulgare*)

3.Positioning of cells by special trapping design in a micro-fluidic channel.

The aim of this work is the penetration and movement of single magnetic particles into the cells on Lab-on-the-chip system.

BP 30.8 Thu 17:15 P3

Nanosized vesicle transport in quasi 1D prepatterned Human Umbilical Vein Endothelial Cells (HUVEC): projecting 2D trajectories into 1D — •Marion Vollmer[1], Matthias Himmelstoss[1], Stefan Zahler[2], and Doris Heinrich[1] — [1]Faculty of Physics and Center for NanoSciences (CeNS), Ludwig-Maximilians-University, Geschwister-Scholl-Platz 1, 80539 Munich, Germany. — [2]Center for Drug Research, Pharmaceutical Biology, Ludwig-Maximilians-University, 81377 Munich, Germany.

Intracellular transport is a regulated process to orchestrate the localisation of vesicles to subcellular compartments. Vesicles attach to microtubules (MT) via motor proteins and are transported to their destination. This directed transport is intercepted by the dissociation of the vesicles from the MT leading to diffusive motion. To distinguish between directed and diffusive motion in the cell, our group developed the TRAnSpORT algorithm [1], based on the analysis of the mean square displacement (MSD). To calculate the vesicular run lengths more precisely we projected 2D trajectories into 1D, thereby reconstructing the MT virtually. This approach was tested in HUVEC that were grown on prepatterned surfaces, generating elongated, quasi-1D cell shapes and which were treated with low doses of the antimicrotubule drug vinblastine. Compared to untreated cells, vesicles in treated HUVEC showed a reduced run length and velocity, indicating the reduction of directed transport processes. This suggests, that the 1D projection is a precise tool to analyse curvilinear trajectories with changing directions of motion. [1] Arcizet et al., PRL, 101(24):248103, 2008.

BP 30.9 Thu 17:15 P3

Mechanical Characteristics of Primary Cilia — •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. One system of interest, from both a biophysical and medical standpoint, is the primary cilium of kidney epithelial cells, which has been demonstrated to act as a flow sensor. The mechanics of this structure is expected to influence the mechano-electrochemical response that characterizes biological ciliary function. We have developed cell cultures that allow us to visualize and manipulate primary cilia. We explore the mechanical properties of cilia using optical trapping and fluorescence microscopy.

BP 30.10 Thu 17:15 P3

Cell stretching with a vertical optical trap — •Kai Bodensiek[1], Schanila Nawaz[1,2], Mikael Simons[2], and Iwan A. T. Schaap[1] — [1]Georg-August-Universität, Göttingen, Germany — [2]Max-Planck Institute for experimental Medicine, Göttingen, Germany

Multiple methods are available to measure cell mechanics. Since most of them operate in the nano-Newton range or higher, they will not only measure but also affect the properties of the cell. Here we describe a method, based on an optical trap to measure the cell response at forces below 20 pN. In contrast to conventional optical trapping is which the bead is moved in the horizontal plane, we have built an instrument in which the bead motion can be manipulated and detected in the vertical direction (perpendicular to the microscope coverslip). Thus a surface bound cell can be compressed or stretched between a single optically trapped bead and the surface; we will present first results obtained on 3T3 fibroblasts. In addition we will present routines to detect contact between the bead and the cell, and methods to minimize the effects of Fabry-Pérot interference between the bead and the surface that is caused by the coherent nature of the laser light.

BP 30.11 Thu 17:15 P3

Quantitative TIRF Microscopy of Fluorescent Layers — •Haugen Grefe and Hans-Günther Döbereiner — Institut für Biophysik, Universität Bremen, Germany

Lamellipodia play an important role for the motility of cells. Our aim is to measure the growth dynamics and thickness of these structures using total internal reflection fluorescence (TIRF) microscopy. Upon sending a laser beam on a cover slip with an angle above the critical angle of total reflection an evanescent intensity field appears in the preparation behind the glass. The penetration depth is in the range of 50 to 1000 nm, which is also the expected thickness of lamellipodia. When one linearly increases the laser angle the fluorescence intensity of excited fluorophores behind the cover slip decreases exponentially. Fitting the intensity as a function of penetration depth gives the size of the fluorescent object. This procedure works well with dyed latex beads with a diameter of 100 to 500 nm. In the next step we will produce fluorescent layers with a defined variable thickness. The intention is to get a scale for measuring dyed lamellipodia as well as to optimize the theoretical background for fitting the intensity result.

BP 30.12 Thu 17:15 P3

Growth dynamics of *Physarum polycephalum* on different length scales — •Christina Oettmeier, Erik Bernitt, and Hans-Günther Döbereiner — Institut für Biophysik, Universität Bremen, Germany

The amoeboid slime mold *Physarum polycephalum* is a big single-celled organism with several hundred or thousands of nuclei. It can reach sizes of 10 to 100 cm or larger. *Physarum* exhibits a wide range of movement patterns, ranging from amoeboid crawling to oscillations with different amplitudes and periods. The most prominent example is the so-called shuttle streaming, the contraction and relaxation of the organism's veins. This rhythmic pattern of contraction and relaxation serves to transport cytoplasm throughout the network and is caused by the contraction of acto-myosin structures.
Microplasmodia, a special growth form characterized by its spherical shape, were used as the starting form to grow networks. High-resolution movies were taken under a bright-field microscope and provide insights into the spatio-temporal dynamics. Pronounced oscillations could be observed and analysed quantitatively: A fast oscillation with a period of 1 to 2 minutes as well as a superimposed slow oscillation with a period of about 20 minutes were found. Lateral contraction waves running along the periphery with a speed of about 10 m/s could also be observed. Additionally, the morphology of the microplasmodia was investigated by transmission electron microscopy (TEM) and scanning electron microscopy (SEM) pictures. Pores with a diameter of about 2 μm were located together with a system of corresponding channels.

BP 30.13 Thu 17:15 P3

Establishment of Cell Polarity in Yeast Saccharomyces cerevisiae — •Ben Klünder[1], Tina Freisinger[2], Jared L. Johnson[3], Roland Wedlich-Söldner[2], and Erwin Frey[1] — [1]Department of Physics, Ludwig-Maximilians-Universität München, Theresienstraße 37, D-80333 München, Germany — [2]Max Planck Institute of Biochemistry, Am Klopferspitz 18, D-82152 Martinsried, Germany — [3]Department of Chemistry and Chemical Biology, Cornell University, Ithaca, New York 14853

Cell polarization is a prerequisite for processes such as cell motility, proliferation, and stem cell differentiation. The yeast Saccharomyces cerevisiae is able to polarize spontaneously in the absence of spatial cues and without help of cytoskeletal structures. The emergence of polarity instead was found to rely on a network of regulatory proteins of the central polarity GTPase Cdc42. However, the fundamental mechanisms for polarity establishment still remain to be identified. Based on new experimental findings we propose a minimal model of cell polarization which uses local self-amplification of activation and recruitment of Cdc42 to establish a stable cap of Cdc42 on the plasma membrane. Using a combination of analytical and numerical methods we study the effect of mutations in Cdc42 regulators, which lead to either loss of polarization or characteristic changes of experimentally accessible observables. Our results are consistent with measurements from in vivo studies and indicate that cell polarization of yeast depends on self-enhanced recruitment of Cdc42 coupled to rapid cycling of GTPase activity.

BP 30.14 Thu 17:15 P3

Interplay Between Compartmentalization of Cells and Tumor

Spreading — •Steve Pawlizak, Anatol Fritsch, Mareike Zink, and Josef A. Käs — Institute for Experimental Physics I, Soft Matter Physics Division, University of Leipzig, Germany

The formation of cellular compartments is a universal and essential process during embryonic development. It generates well-defined boundaries and barriers for various differentiated cell types. Cells of the same type adhere better to each other, whereas mixtures of different migrating cell types segregate. Studies in the field of developmental biology show that the interplay between single cell biomechanics, cell adhesion, and cell migration contributes to the formation of cellular compartments by causing a surface tension at the compartment boundaries.

In this context, we investigate to which extend the physical principles described above affect tumor growth and spreading between compartments. It has been observed that metastasis and tumor aggressiveness are correlated with a loss of epithelial characteristics and the acquirement of a migratory phenotype. Due to this behavior, tumor cells are able to overcome compartment boundaries. Further studies indicate that surface tension plays a crucial role for tumor progression, but this has not been systematically investigated so far. We apply a variety of techniques such as "Optical Stretching", scanning force microscopy, and droplet cultures to study the cellular mechanical properties and interactions of healthy and malignant cells.

BP 30.15 Thu 17:15 P3

Granule motion in pathogenic amoebae studied with particle-tracking methods — •Julia Reverey[1], Matthias Leippe[2], and Christine Selhuber-Unkel[1] — [1]Institute for Materials Science, Biocompatible Nanomaterials, Christian-Albrechts-University, Kaiserstr. 2, 24143 Kiel, Germany — [2]Zoological Institute, Zoophysiology, Christian-Albrechts-University, Am Botanischen Garten 1-9, 24118 Kiel, Germany

Entamoeba histolytica and Acanthamoeba are parasitic amoebae which can cause severe diseases, such as human amoebiasis, amoebic encephalitis and keratitis, respectively. They destroy target cells by an extracellular killing mechanism that is induced by the formation of a close contact between amoeba and target cell. Subsequently, granules that contain membrane-active proteins are transported to the contact site between amoeba and target cell. Therefore, the intra-amoebic motion of granules plays an essential role for the pathogenicity of the amoebae. For a deeper understanding of this amoebic killing mechanism, we record sequences of granule movement with phase-contrast microscopy in combination with a high-speed camera under physiological conditions. The motion of the granules within the amoeba is evaluated using particle tracking algorithms. In our final analysis, we particularly focus on distinguishing between passive diffusion and active transport of the granules.

BP 30.16 Thu 17:15 P3

Setup and improvements of dual trap optical tweezers for analyzing the cytoskeleton of epithelial cancer — •Thomas Fröhlich[1], Tobias Paust[1], Michael Beil[2], and Othmar Marti[1] — [1]Institute of Experimental Physics, Ulm University — [2]Department of Internal Medicine I, Ulm University

Optical trapping of dielectric particles is a powerful tool to manipulate and measure biological objects such as cells. Based on acousto-optic deflectors (AODs), quadrant photo diode detection, high speed camera and piezo electric sample positioning, we have built an optical tweezers device for a specially constructed optical microscope. This instrument has two permanent traps. Due to the two axes of the AOD scanning system, one trap can oscillate freely in the image plane and since there are no moving masses, we gain access to a high frequency range. The second trap is adjusted manually with a mirror and is used as a static measure point to gain information about the mechanical properties of the space between the two traps. Becauce of the high performance of the AOD system, it is also possible to get additional traps by time sharing for more complex measurements. To stabilize the system and to minimize the adjustment time, a rail system for the optical components is used.

With this instrument we can manipulate and measure mechanical properties of biological samples in a wide frequency range. The efficiency of this setup was demonstrated with measurements of the dynamic shear modules of the intermediate filament cytoskeleton of pancreatic carcinoma cells.

BP 30.17 Thu 17:15 P3

Collective dynamics during the early stage of biofilm formation — •Matthias Theves and Carsten Beta — Biologische Physik, Universität Potsdam

Biofilms are communities of sessile bacteria, embedded in an extracellular polymeric structure (EPS), which form at solid-liquid or liquid air interfaces. First, we use biocompatible microfluidic channels together with time-lapse microscopy to study the recruitment of planktonic Pseudomonas putida to a glass surface as well as the subsequent development from attached colonies leading to the mature biofilm. The results serve as a starting point for comparable experiments with Bacillus subtilis, a model organism for biofilm formation capable of 'swarming motility', a state of rapid, flagella-driven colony expansion across surfaces. We finally develop a high-speed setup for digital inline holography (DIH) to investigate the full three-dimensional picture of the collective motion of both swimming and surface attached bacteria that initiates biofilm formation. In future experiments microfluidic tools will help us to understand the initial interactions and manipulate environmental cues which trigger the biofilm development.

BP 30.18 Thu 17:15 P3

Correlative Microscopy: On the position of extracted pancreatic carcinoma cells — •Tobias Paust[1], Thomas Föhlich[1], Samuel Vollmer[1], Tobias Pusch[1], Paul Walther[2], Michael Beil[3], and Othmar Marti[1] — [1]Institute of Experimental Physics, Ulm University — [2]Central Electron Microscopy Unit, Ulm University — [3]Department of Internal Medicine I, Ulm University

Microrheology measurements of particles which are embedded in the cytoskeleton of extracted carcinoma cells show the mechanical properties of the network. The network stiffness then can be calculated dependent on the position of the bead.

To ensure that a measurement of a cells shows up correct values for storage and loss modulus the same cell should be checked in the Electron Microscope. Therefore we developed a sample chamber which makes it possible to find the position of the microrheological measurement in the Electron Microscope. So only particles in a proper position can be used for calculations.

On this poster we want to show how to find cells and also take a look on the statistics on the amount of lost cells during the preparation process for the Electron Microscope.

BP 30.19 Thu 17:15 P3

Microrheology: A new algorithm for the conversion of mean squared displacement to dynamic shear moduli — •Tobias Paust[1], Anke Leitner[1], Michael Beil[2], and Othmar Marti[1] — [1]Institute of Experimental Physics, Ulm University — [2]Department of Internal Medicine I, Ulm University

For describing the mechanical properties of a viscoelastic medium a possible way is to measure the thermal motion of a particle embedded in the medium and compute the unilateral transform.

The conversion of the mean squared displacement to the dynamic shear moduli is in the focus of interested in this work. We provide a new method for calculating the Laplace transform and therefore gather information about the mechanical properties of the sample. A superposition of well-defined analytical functions which are fitted to the measured data leads to the frequency-dependent storage and loss moduli of the system. In that way one can describe the viscoelastic behavior of the system in the needed frequency range without any approximation.

We show examples of mean squared displacements and the calculations of the elastic and diffusive part of different systems.

BP 30.20 Thu 17:15 P3

Changes of Min-protein patterns in growing Escherichia coli — •Mike Bonny[1], Elisabeth Fischer-Friedrich[2], and Karsten Kruse[1] — [1]Theoretische Physik, Universität des Saarlandes, 66041 Saarbrücken — [2]Department of Chemical Physics, Weizmann Institute of Science, Rehovot 76100 Israel

The position of the division site in the rod-like bacterium E. coli is determined by the Min proteins. In a wild-type bacterium, prior to division, the Min proteins organize into a standing wave with a single node in the cell center, thereby selecting the cell center as division site. If the bacterium is prevented from dividing and grows longer, we see that in a considerable fraction of bacteria, the pattern changes first into a travelling wave that starts at one cell pole and disappears at the opposite pole before re-emerging at the original pole. After a further increase in cell size, the pattern changes again into a standing wave, now with two nodes. In our work, we present an experimental and a theoretical investigation of these transitions.

BP 30.21 Thu 17:15 P3

Regulation of Dynamic Cell Response with Laterally Confined Domains Embedded in Supported Membranes — •Thomas Kaindl[1], Stefan Kaufmann[1], Oleg Konovalov[2], Ana Martin-Villalba[3], and Motomu Tanaka[1] — [1]PCI, Universität Heidelberg, Germany — [2]ESRF, Grenoble, France — [3]DKFZ, Heidelberg, Germany

Highly uniform and strongly correlated domains of synthetic, fluorinated lipids were incorporated into solid supported lipid membranes to act as the confined, multivalent sites to regulate cell surface interactions. It was demonstrated that fluorinated lipids form monodispersive domains whose domain size and inter-domain correlation can precisely be controlled by the length of fluorocarbon chains. The fluorinated lipid domains were modified with carbohydrates or an apoptosis-inducing protein ligand (CD95L) which could successfully activate the specific cell response of macrophages and cancer cells. The dynamic spreading of murine macrophage and apoptosis of pancreatic cancer cells were analyzed by a combination of confocal microscopy and reflection interference contrast microscopy (RICM). The lateral confinement of ligand molecules revealed a significant effect on the adhesion behavior of cells.

BP 30.22 Thu 17:15 P3

The Role of Microtubules in Cell Motility — •Matthias Rakowski, Börn Meier, and Doris Heinrich — Faculty of Physics and Center for NanoScience (CeNS), Ludwig-Maximilians-Universität München, Geschwister-Scholl-Platz 1, 80539 München, Germany

The ability of cells for self-determined motility plays a crucial role in many biological processes, like food gathering of single amoeba or tissue invasion of whole cell ensembles during angiogenesis. In order to migrate, cells require advanced control over their cytoskeleton, in principle consisting of the actin cortex and microtubules. While many studies examine the influence of perturbations of the actin cortex in Dictyostelium discoideum cells, few address migration with depleted microtubules. We implemented an analysis method based on examination of increasing (gain) and decreasing (loss) cell areas between distinct time steps. This analysis is combined with skeletonisation, a morphological operation on binary images to transform a shape to a line as shown in Yuan Xiong et al [1]. This operation emphasizes geometrical and topological properties. Our statistical analysis of pseudopod dynamics, in terms of angle distributions, pseudopod lifetime, and the distinction between directed and random phases of migration obtained by our Transport-algorithm [2], permits an accurate description and quantification of cell migration and therefore will help to elucidate the role of microtubules in cell motility.

[1] Xiong et al., BMC Sys. Biol. 4, 33
[2] Arcizet et al., PRL 101, 248103

BP 30.23 Thu 17:15 P3

Optical trapping and motility of trypanosomes — •Eric Stellamanns[1], Sravanti Uppaluri[1], Niko Heddergott[3], Markus Engstler[3], and Thomas Pfohl[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Department of Chemistry, University of Basel, Basel, Switzerland — [3]Department of Zoology, University of Würzburg, Würzburg, Germany

Trypanosomes are unicellular human bloodstream parasites and the causative agent of the so called African sleeping sickness. They are spread by the bite of the tsetse fly and represent a thread to an estimated number of 60 million people in 36 sub Saharan countries. Motility is of paramount importance to cell survival and hence pathogenicity of the parasite. Using optical tweezing methods in microfluidic cell culture environments we are able to analyze cellular motility to a great detail and measure the forces they generate. We find that trypanosome propagation forces are dependent on cell cycle and growth of the flagellum. Furthermore we describe that motility has a broad spectrum not only over the population but also on the single cell level.

BP 30.24 Thu 17:15 P3

Rheology of suspended cells: microscopic mechanisms and biological relevance — Franziska Lautenschläger, Andrew Ekpenyong, Danielle Kaminski, Graeme Whyte, and •Jochen Guck — Cavendish Laboratory, University of Cambridge, UK

The mechanical properties of cells are largely governed by the cytoskeleton, an internal hybrid polymer network, and its connection to the cell nucleus. We have used an optical stretcher to investigate the microscopic origin of the rheological properties of various cells in suspension, which differ characteristically from attached cells. Suspended cells are more amenable to polymer theoretical comparison because their cytoskeleton is rather isotropic and not confounded by stress fibers. Also the function of molecular motors is contrary to that of attached cells, and leads to a viscous softening in suspension. Finally, cell rheological properties will be discussed in the context of stem cell pluripotency, epigenetic chromatin condensation, corresponding changes during differentiation and in laminopathies.

BP 30.25 Thu 17:15 P3

Nonlinear Cellular Deformation Response to Optical Forces — •Tina Händler, Tobias Kiessling, Roland Stange, and Josef Käs — University of Leipzig, Germany

A number of diseases are caused by alterations in the cytoskeleton, a highly dynamic protein network that spans the whole cell. The mechanical properties of the cytoskeletal proteins determine the cellular mechanics. Therefore, changes in these proteins are reflected in the cells' response to an applied stress. With an Optical Stretcher, global deformation behavior of suspended cells can be investigated. Optically induced forces are employed to mechanically characterize cells over a wide range of stress, accounting for the proteins' distinct elastic properties depending on their concentration and the mechanical stress they are subject to. At very small stresses, most cells show a linear deformation behavior that is dominated by the actin cortex. Being subject to larger stresses, cells are deforming non-linearly even at relatively small stresses, resulting in a rupture-like, visible restructuring of the cytoskeleton. However, the cells do not completely lose their mechanical integrity, indicating that other cytoskeletal components might account for the cells' viability after the rupture event under physiological circumstances. Modifying the cytoskeletal proteins with chemical agents allows a differentiated investigation of the observed phenomena and helps to understand how cells regulate their mechanical properties.

BP 30.26 Thu 17:15 P3

Flexible three-dimensional scaffolds for cell adhesion studies — •Thomas Striebel[1,2], Franziska Klein[1], Denis Danilov[1], Thomas Boehlke[1], Martin Wegener[1], Martin Bastmeyer[1], and Ulrich S. Schwarz[2] — [1]Karlsruhe Institute of Technology (KIT) — [2]ITP, University of Heidelberg

Tools from materials science such as microcontact printing of adhesive patterns or preparation of flexible polymer substrates are widely used for cell culture experiments. However, most of these studies are restricted to flat substrates, although many cellular functions in a tissue context are known to be closely related to the three-dimensionality of the natural environment. We have recently shown that direct laser writing is a versatile technique to fabricate tailored 3D-scaffolds that are sufficiently elastic such that they can be deformed by muscle cells [1]. Here we demonstrate that also softer scaffolds can be produced that are deformed by weaker tissue cells such as fibroblasts. In order to evaluate scaffold deformation in a comprehensive manner, we apply finite element modeling both to the synthetic scaffolds and for implementing a novel biophysical model for cell contractility.

[1] F. Klein, T. Striebel, J. Fischer et al., Adv. Mater. 2010, 22(8), 868-71.

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Flow-Alignment Coupling in the Cortex of C. Elegans Embryo — •Guillaume Salbreux[1,2], Sundar Naganathan[2], Jean-Francois Joanny[3], Frank Julicher[1], and Stephan W. grill[1,2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max Planck Institute for Cell Biology and Genetics, Dresden, Germany — [3]Institut Curie, Paris, France

In the nematode C.Elegans embryo, anteroposterior polarization is ensured by a cortical flow powered by myosin activity (Mayer&Al, Nature, 2010). Here we investigate the consequence of this flow on the alignment of actin filaments in the cortex. A generic hydrodynamic theory of the actin cortex predicts the formation of an actin ring at the boundary between the anterior and posterior region and the formation of an ingression which may explain the apparition of a pseudocleavage furrow. The alignement can be characterized with a nematic order that we measure on embryos carrying a Lifeact probe allowing to visualize the actin cortex. Strikingly, we have been able to observe this ring and a coupling between flow and order parameter at different stages of the polarization flow. Such coupling may be a generic feature in biological systems involving actin networks.

BP 30.28 Thu 17:15 P3

Exploring the microtubules role in nuclear centering of S. pombe — •Damien Ramunno-Johnson[1], Nicola Maghelli[1], Vladimir Krstic[1], Nenad Pavin[1,2], Alexander Krull[1], Frank Jülicher[2], and Iva Tolić-Nørrelykke[1] — [1]MPI-CBG, Dresden, Germany — [2]MPI-PKS, Dresden, Germany

In the fission yeast *Schizosaccharomyces pombe*, the nucleus ia positioned at the cell center. Since the nucleus determines the cell division site, nuclear centering is crucial for symmetrical cell division. Microtubules push against the cell ends and exert force on the nucleus, but how the cell regulates the centering remains unknown. Here we tackle this problem by using a combination of live cell imaging and theoretical modeling. We show that the nuclear centering efficiency is affected by the microtubule catastrophe rate.

To explore the effects of microtubule dynamics on nuclear centering, a mutant *S. pombe* strain was created to investigate of the role of kinesin-8 in microtubule catastrophe regulation. We found that centering functions better in the wild type. It is necessary to model this system as a dashpot and a spring in parallel. Taken together, our experimental and theoretical results provide a novel centering mechanism where kinesin-8 motors increase the efficiency of nuclear centering.

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Quantification of adhesion of malaria infected erythrocytes on functionalized surfaces mimicking placental tissues. — •Harden Rieger[1,2], Hiroshi Yoshikawa[1], Michael Lanzer[2], and Motomu Tanaka[1] — [1]Physical Chemistry of Biosystems, Institute of Physical Chemistry, University of Heidelberg, D69120 Heidelberg, Germany — [2]Department of Infectious Diseases, Parasitology, University of Heidelberg, Medical School, D69120 Heidelberg, Germany

Pregnancy-associated malaria is a serious health issues in tropical countries, as it causes an increase of newborn and maternal mortality. It has been demonstrated that the glycoaminoglycans, such as chondroitin sulfate A (CSA), play a major role in the adhesion of infected erythrocytes to placental tissue, but a quantitative study showing their relative contributions is still missing. The primary aim of this study is to design a quantitative model of placenta surface by functionalization of planar lipid bilayer membranes with CSA at defined surface densities. By controlling the self-assembling of anchor molecules, the average distance of CSA <d> can be regulated within nm accuracy. The specific adhesion of infected erythrocytes was firstly demonstrated on the membrane with <d> = 5.4 nm: In contrast, healthy erythrocytes show no detectable adhesion on the same surface. Furthermore, we found that the infected cells can detect a small change in <d>, undergoing a very sharp binding-unbinding transition. The strength of cell adhesion was quantitatively measured by two means: (a) analysis of cell shape near the surface and (b) a non-invasive assay that utilizes intensive shock wave generated by a ps laser pulse.

BP 30.30 Thu 17:15 P3

Direct quantitative evidence for the presence of optical elements in the vertebrate retina — •Moritz Kreysing, Zuzanna Blaszczak, Lars Boyde, Kevin Chalut, Kristian Franze, and Jochen Guck — Department of Physics, University of Cambridge, J.J. Thomson Avenue, Cambridge CB3 0HE, UK

The vertebrate retina is an optics puzzle: light, before reaching the photoreceptor cells, needs to propagate through hundreds of microns of living neuronal tissue. Whereas the retina is commonly said to be transparent, little is actually known about its optical transmission characteristics. In recent years we have been reporting on both the optical properties of retinal glia cells as well as photoreceptor nuclei which seemingly have developed specific optical properties that facilitate efficient light transmission in addition to their usual biological function. With the current study we present the direct and quantitative observation of light modulation due to the presence of these optical elements inside the inner retina. A discussion of the implications of our finding for the understanding of the visual process concludes the talk.

BP 30.31 Thu 17:15 P3

Dynamics of P-granule formation and localization in C.elegans embryos — •Jöbin Gharakhani[1], Chiu Fan Lee[1], Clifford P. Brangwynne[1,2], Anthony A. 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

During embryonic development, precursor germ cells contain aggregates of proteins and RNA known as germ granules ("P-granules"), which are important in the specification of a functioning germ line. In the first cell division of the fertilized egg of the worm, C.elegans, P-granules segregate towards the posterior side of the cell; upon cell division, they are found only in the posterior daughter cell. This segregation occurs through preferential growth of the P-granules on the posterior side of the cell. This preferential growth is maintained by a gradient in the concentration of the protein MEX-5 along the anterior-posterior axis of the cell. MEX-5 appears to decrease the saturation point for a phase transition into the condensed granule phase along this axis, thereby allowing a spatially asymmetric nucleation and growth. We use a simulation based on the Lifshitz-Slyozov model for droplet growth to study this system, where the model is expanded to include a spatial supersaturation gradient. We find that P-granules preferentially stay at the posterior side due to two effects: i) the lower saturation point allows for greater P-granule growth, and ii) larger P-granules diffuse more slowly.

BP 30.32 Thu 17:15 P3

Search strategy for a lost kinetochore based on random angular movement of the microtubule — •Nenad Pavin[1,2], Iana Kalinina[3], Amitabha Nandi[1], Alexander Krull[3], Benjamin Lindner[1], and Iva M. Tolic-Norrelykke[3] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Faculty of Science, Zagreb, Croatia — [3]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

In living cells, proper segregation of genetic material between the two daughter cells requires all chromosomes to be connected to the spindle microtubules. Linkers between chromosomes and MTs are kinetochores (KCs), protein complexes on the chromosome. In fission yeast, KCs are clustered at the spindle pole body (SPB), which facilitates their interaction with MTs that grow from the SPB. If the spindle is compromised, it is able to recover including capturing KCs that have been lost in the nucleoplasm. It is, however, unknown how MTs find lost KCs. We found that lost KCs can be captured by random angular movement of the microtubule. By using live cell imaging, we observed that astral MTs pivot around the SPB, in cell with and without lost KCs. By studying relationship between the MT angular diffusion and MT lengths, we found that this movement is most likely driven by thermal fluctuations. In addition, we found that KCs and astral MTs by performing random movement explore comparable fraction of space. Finally, by introducing a theoretical model, we show that the process of KC capture can be explained by the observed random movement of astral MTs and of the KC.

BP 30.33 Thu 17:15 P3

Forces in cellular growth and division — •Nils Podewitz — Group for Biophysics & Evolutionary Dynamics, MPI for Dynamics & Self-Organization, Göttingen, Germany

When cells grow and divide to from clusters, colonies or dense tissues, they exert mechanical forces onto their surroundings in order to free space for new cells. Obviously there is a maximal force at which cells will stop growing. Until now it is not fully understood why they stop growing and what these stall forces are.

To study this phenomenon we encaged yeast cells in a microfluidic chamber made of an elastic polymer. The deformation of the chamber wall then let us deduce the pressure exerted by the cells, providing us with a relation between cell growth and the forces involved.

Our findings could be relevant to the early stages of biofilm formation as well as allowing insight into tissue dynamics in higher organisms.