BP 6: Poster I

Topics: Active matter (6.1 - 6.9); Biomaterials and biopolymers (6.10 - 6.19); Cell adhesion and migration and multicellular systems (6.20 - 6.33); Cell mechanics (6.34 - 6.51); Cytoskeletal filaments (6.52 - 6.67); Statistical physics of biological systems (6.68 - 6.83)

Time: Monday 17:30–19:30 Location: Poster B2

BP 6.1 Mon 17:30 Poster B2

Nano-stir bars for perturbing biofluid microdroplets in a microfluidic channel — •Mithun Thampi, Pierre-Yves Gires, and Matthias Weiss — Experimental Physics I, University of Bayreuth, Germany

Studying reactions in the cytoplasm of living cells or in biofluid droplets, e.g. produced in microfluidic channels for lab-on-chip applications, is key for elucidating the dynamics of living matter. However, due to their small dimensions, a controlled and gentle stirring of the interior of biofluid droplets, e.g. for speeding up diffusion-limited reactions, has remained challenging. Here we report on an approach to synthesizing few micrometers long magnetic nano-stir bars (NSBs) for perturbing biofluid microdroplets. NSBs were produced by aligning Fe_3O_4 nanoparticles via magnetic fields and adding a biocompatible silica coating, followed by magnetic sedimentation to extract the required length range from the polydisperse bulk solution. Scanning electron microscopy confirmed the successful production and isolation of NSBs. Incorporating NSBs into aqueous biofluid microdroplets, produced at PDMS-based microfluidic junctions within a hydrophobic carrier fluid, and addressing them with alternating magnetic fields resulted in a rotational motion of NSBs with angular frequencies in the range 0.01-10 Hz. The resulting gentle mixing of the droplets' interior was monitored via fluorescence microscopy.

BP 6.2 Mon 17:30 Poster B2

A phase field crystal approach to active systems with inertia — •Dominic Arold and Michael Schmiedeberg — Institut für Theoretische Physik 1, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstrasse 7, 91058 Erlangen, Germany

A phase field crystal approach for active systems consisting of particles with inertia is investigated. In our model the direction of the inertia given by the velocity can be different from the direction of the self-propulsion due to the activity. The implementation of the inertia is motivated by the derivation of an phase field crystal model of underdamped passive particle from a dynamical density functional theory [1], while the activity is modelled as in a phase field crystal model of active systems without inertia [2,3]. In the overdamped regime the results of the latter model can be reproduced including the formation of stable resting or migrating crystals. In the opposite underdamped regime where inertial effects become relevant the migrating crystalline order is destroyed due to the high self-propulsion strength and a chaotic behaviour is observed instead.

[1] A. J. Archer, J. Chem. Phys. **130**, 014509 (2009).
[2] A. Menzel and H. Löwen, Phys. Rev. Lett. **110**, 055702 (2013).
[3] A. Menzel, T. Ohta and H. Löwen, Phys. Rev. E **89**, 022301 (2014).

BP 6.3 Mon 17:30 Poster B2

The Role of Loops in Transport Networks — •Leonie Bastin, Mirna Kramar, and Karen Alim — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Transport networks play an important role in living organisms and man-made structures. Treelike networks are found to be the most efficient transport networks. However, in biology, many networks grow into loop containing structures. It is still an open question, why loops are favored by some organisms. We investigate the effect of loops on the transport efficiency in a network, using the model organism *Physarum polycephalum*, which grows as a highly interconnected tubular network. Selforganized contractions drive the fluid flow in these networks. For our studies, we developed a method to incorporate fluorescent beads into *P. polycephalum*'s streaming cytoplasm and use particle tracking for flow visualization. We prepare both treelike and loop-containing networks and compare measured flow velocities. Our findings suggest that loops increase the transport homogeneity in *P. polycephalum*. In contrast, the foraging fronts of the organism lead to hierarchically organized networks.

BP 6.4 Mon 17:30 Poster B2

Microscopic active systems learning in noisy environments — •Santiago Muiños-Landin and Frank Cichos — University of Leipzig. Peter Debye Institut for Experimental Physics

Optimal behavior at the microscopic scale is a particularly challenging achievement. In addition to the intrinsic stochasticity of the motion observed in microscopic swimmers, the information that can be collected by active agents to optimize their behavior at this regime is usually sparse and noisy. However biological systems manage to face such challenge through different strategies depending on the propulsion and the sensing mechanisms coupled in robust enough sensory-motor processes. These achievements have been also recently observed in an artifical context, where following learning strategies, synthetic swimmers can also optimize their behavior in simple navigation tasks and also a significant influence of noise in the optimality of a strategy has been reported. Here we present a platform to study in detail such influence of noise in the dynamics and the behavior of a self-thermophoretic swimmer. Exploring the possibility of taking advantage of such fluctuations in single tasks but also considering collective behavior.

BP 6.5 Mon 17:30 Poster B2

Feedback Control of Active Microswimmers to Imitate Phototaxis — •Alexander Fischer and Frank Cichos — Universität Leipzig

Collective motion created by the interaction of autonomous individuals plays a major role in flocks of birds, bacterial growth or the motion of robotic swarms. Sensing and reacting to signals is a fundamental issue of life. Microswimmers, which are artificial objects that mimic the active motion of biological systems, do not have such sensing and response features built in yet, but may gain them through an external control of their propulsion. Here we explore an information exchange between artificial microswimmers by computer-controlled feedback processes. We have created a setup where multiple active microswimmers can react to their position in space or their distance to other microswimmers. Our system consists of autonomous agents performing directed motion in a plane and their orientation is subject to noise. The speed of the agent slows down in those regions where it measures a higher concentration of messengers. Thus, the probability of presence of the agent is higher in regions with higher concentration. According to Volpe et al. [1], a change between segregation and aggregation of the agents in the high messenger concentration regions can be achieved by introducing a delayed response to the messenger concentration.

[1] M. Mijalkov, A. McDaniel, J. Wehr, G. Volpe, Phys. Rev. X 6, 011008 (2016)

BP 6.6 Mon 17:30 Poster B2

Capillary condensation forces between inclusions in an active bath — •Milos Knezevic and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

We present a systematic study of capillary condensation forces between objects immersed in an active bath of microswimmers. We study two types of active baths, consisting of either Active Brownian particles (no hydrodynamic interactions) or spherical squirmers (with hydrodynamic interactions). Inclusions of various shapes and sizes are considered. We find that forces between inclusions can be either attractive or repulsive, depending on the density and motility of microswimmers, and the geometric properties of inclusions. We explore ways of controlling these forces, which is relevant for self-assembly.

BP 6.7 Mon 17:30 Poster B2

Thermoviscous flows at reduced heating impact — •Matthias Loidolt, Matthaeus Mittasch, Archit Bhatnagar, Anatol Fritsch, and Moritz Kreysing — MPI of Cell Biology, Dresden

Recently it was demonstrated that thermoviscous flows can be used to move the cytoplasm of cells and developing embryos (1). These

flows are induced by laser scanning of a temperature spot through the cytoplasm, and reach velocities that are comparable with flow velocities happing during early stages of embryogenesis. As a side effect, this laser scanning introduces weak temperature gradients, that are on the order of 1-2 kelvins when time-averaged. While this is sufficient to avoid side effects in heterothermic animals, some mammalian cells might require even more stable temperature conditions. Here, we present that exploiting symmetry relations during laser scanning, we can still generate significant flow fields, while greatly reducing time-averaged temperature gradients. Specifically we find that scan paths that visit every point in the sample equally often can still be used to cause localized flows. At the same time the resulting temperature distributions are near homogenous across the region of interest and can therefore be much better compensated for by ambient cooling.

(1): Mittasch et al., " Non-invasive perturbations of intracellular flow reveal physical principles of cell organization", Nature Cell Biology 1 (2018)

BP 6.8 Mon 17:30 Poster B2

Taming the Factor: Upstream dynamics of Circular Dorsal Ruffle (CDR) regulation — •Malte Ohmstede and Hans-Günther Döbereiner — Institut für Biophysik, Universität Bremen

CDRs are actin based, ring-shaped undulations of the dorsal membrane in, among others, fibroblast cells. CDRs are involved in macropinocytosis, a process in cell proliferation and are also a gateway for various pathogens to enter the cell. Stimulation of CDRs is achieved by various growth factors, e.g. Platelet Derived Growth Factor (PDGF), stimulating their corresponding receptor tyrosine kinase (RTK). The RTKs then trigger a signalling cascade resulting in the formation of CDRs and ultimately macropinocytosis, collapsing CDRs into large vesicles which are then transported to the nucleus. Delivery of growth factors in vitro can be done either passively by relying on growth factors of unknown low concentrations contained in FBS or by explicitly adding known concentrations to the medium. Depending on PDGF concentration, a clear difference in CDR shape is observed. Larger concentrations result in CDRs spanning over most of the lammelipodium, whereas low concentrations yield small rings. Upon stimulation of the entire lammelipodium, most RTKs are consumed, resulting in a recovery time needed for the cell to re-express the receptors before being able to be stimulated again. Using a combination of microfluidics and microcontact printing, it is possible to observe medium switching at precise times and without imaging interruption. Thus, cell reaction and recovery times can be precisely measured.

BP 6.9 Mon 17:30 Poster B2

MT-kinesin bundle and cross-linked network formation — •Amna Abdalla Mohammed Khalid[1], Fanomezana Moutse Ranaivoson[2], Anne Houdusse[2], and Christoph F. Schmidt[1,3] — [1]Drittes Physikalisches Institut - Biophysik, Fakultät für Physik, Georg-August-Universität, Göttingen, Germany. — [2]Structural Motility Group, Institut Curie, Paris, France — [3]Department of Physics, Duke University, Durham, USA

The mitotic kinesin-like protein 2 (MKLP2), is an N-terminal kinesin of the kinesin 6 family. MKLP2 plays critical roles in mitosis, in particular for the metaphase to anaphase transition and for cytokinesis. This kinesin motor is likely to have a diverging mechanism due to several inserts near the motor domain and the neck-linker which make the motor domain $\sim$ 60% larger than that of other kinesins. Its neck-linker is four times longer than that found in other kinesins. We studied dimeric truncated MKLP2 in vitro motility experiments. It is an active motor, although we have not found any processive motility yet in single-molecule assays. A conspicuous feature of this kinesin is its high microtubule (MT) bundling activity. MKLP2 has the ability to form 2D and 3D strongly bundled cross-linked MT networks that evolve and coarsen slowly in time over many hours. We hypothesize that these bundled networks are occurring as a collective dynamic phenomenon based on weak and reversible interactions between the motors and the microtubules.

BP 6.10 Mon 17:30 Poster B2

Hofmeister series for RNA and metal cations: Binding affinities and kinetics and thermodynamics from all-atom molecular dynamics simulation — Sergio Cruz-León and •Nadine Schwierz — Department of Theoretical Biophysics, Max Planck Institute of Biophysics, Max-von-Laue-Str. 3, 60438 Frankfurt, Germany.

RNA folding and function is crucially governed by metal cations. In addition to valence and concentration, the ion type is decisive in processes like folding, or interaction with other molecules. In spite of its biological importance, unraveling the molecular mechanism of ion-specific effects from experiments is challenging due to their limited spatial and temporal resolution. To fill this gap, we combine all-atom molecular dynamics simulation and advanced sampling techniques, to gain insight into the microscopic interactions between an RNA dinucleotide and metal cations. Our results show ordering of the ions according to binding affinities and exchange kinetics. Particularly, direct and reversed Hofmeister series are found to hold true for the interaction with backbone and nucleobase, respectively. We further include the microscopic level of understanding into Poisson-Boltzmann theory to calculate ion competition constants for monovalent ions which agree well with recent experiments. This detailed description of metal cation-RNA interactions provides the molecular origin of ion-specific effects for cations and RNA, being a tool to boost the modeling of complex RNA-cation phenomena.

BP 6.11 Mon 17:30 Poster B2

Differential uptake of graphene quantum dots into human cell lines — •Jennifer Kurth[1], Stefan Fasbender[1], Marina Ludescher[2], Hans Neubauer[2], and Thomas Heinzel[1] — [1]Condensed Matter Physics Laboratory, Heinrich-Heine-University Düsseldorf — [2]Department of Obstetrics and Gynecology, University Hospital Dusseldorf

Fluorescent graphene quantum dots (GQDs) are prepared by the established recipe of Qu et al. [1], using citric acid as carbon source and diethylentriamine as reduction agent. The breast cancer cell lines MCF-7 and MDA-MB-231 and the non-tumorigenic cell line MCF-10A are exposed for up to 48 h to GQDs at a concentration of 500 ug/ml. Flow cytometry and fluorescence spectroscopy are used to analyse the time dependent uptake of the GQDs into the cells. The number of incorporated GQDs is estimated to be in the range of 10 and 50 million per cell for MCF-7 and MDA-MB-231 cells and around 0.5 million for MCF-10A cells. [1] Qu et al., Light: Science & Applications, 2015, 4, e364

BP 6.12 Mon 17:30 Poster B2

Investigating the morphology and nanomechanical properties of snake scale microstructures — •Loïc Musy[1], Iaroslav Gaponenko[1], Raul Gonzalez[2], and Patrycja Paruch[1] — [1]DQMP, University of Geneva, Switzerland — [2]Vivarium de Meyrin, Geneva, Switzerland

Epithelial microstructures in living organisms can inspire biomimetic approaches to materials development, and provide a fascinating window into the evolutionary interplay between environmental constraints and phylogenetic relations.

Here, we study the morphology and mechanical properties of snake scale microstructures, at a macroscopic level using scanning electron microscopy and stress-strain measurements, and at the much less studied nanoscale level via a range of scanning probe microscopy techniques. Investigating sheds from over 20 snake species in 6 different families provided by the Meyrin Vivarium, in each case we fully characterise ventral, dorsal and side scale morphology, and local as well as macroscale response to normal and lateral forces. We find relatively homogenous pattering of the microstructures on ventral scales, possibly as a result of an optimisation for sliding motion, while dorsal scale microstructure patterns vary widely from species to species.

At the nanoscale, we identify very local regions in the microstrucure, particularly on the ventral scales, that dominate the mechanical response of the system.

BP 6.13 Mon 17:30 Poster B2

Probing the Escalation of DNA-Polymerization in Thermal Traps — •Christina Felicitas Dirscherl and Dieter Braun — Systems Biophysics, LMU Munich, Germany

Starting conditions with highly diluted monomers and the 'tyranny of the shortest' are the main problems for de novo strand formation of DNA/RNA on early earth. A possible scenario that could have overcome these issues are thermogravitational traps. We demonstrated that theses traps can accumulate solutions of single molecules at least 35-fold within 30 hours despite their high diffusivity, and that both monomers and activation chemistry molecules (carbodiimide EDC [1]) can be co-accumulated. We could prove that EDC - which is a replacement for the prebiotically plausible cyanoimidazole - polymerizes RNA as well as DNA bases, however only up to 8-mers. Also concentrations of the longer strands decrease exponentially. In thermogravitational traps the accumulation of DNA strands is exponentially

length dependent ([2]). Therefore, the trapping procedure is expected to significantly increase the probability that longer strands are linked together. If additionally two complementary monomers are present in the system self-templated ligation can take place which can lead to an escalation of strand formation ([3]).

[1] M. Jauker, H. Griesser and C. Richert, Angew Chem Int Ed 2015 Nov 23; 54(48): 14564-9

[2] C. B. Mast, S. Schink, U. Gerland and D. Braun, PNAS 110(20), 8030-5 (2013)

[3] T. A. Lincoln and G. F. Joyce, Science 323.5918 (2009): 1229-1232

BP 6.14 Mon 17:30 Poster B2

Movement of DNA within microporous materials in an electric field — •Natascha Heinsohn, Robert Niedl, and Carsten Beta — Universität Potsdam, Potsdam Golm, Deutschland

We performed experiments with DNA fragments in different microfibre materials to investigate the molecular interaction of biopolymers under electrical force. For our experimental set up we prepared printed electrodes with conductive ink to apply a constant electric field within the fibre network. We could observe differences in mobility of DNA fragments in organic and inorganic fibre materials. Our main focus of interest is to indentify and understand these observations in dependence on DNA properties like length and structure together with fibre properties and applied electrical force. This will influence our development of low-cost and disposable devices for point-of-care diagnostics.

BP 6.15 Mon 17:30 Poster B2

A selection mechanism to emerge the first functional sequences — •Alexandra Kühnlein[1], Hannes Mutschler[2], Dieter Braun[1], and Christof Mast[1] — [1]Systems Biophysics, Ludwig-Maximilian University Munich — [2]MPI of Biochemistry,Martinsried

Life has managed to transfer sequence information on Earth for about 4 billion years despite the high complexity and short lifetime of oligonucleotides and maintained the information against degradation and dilution. To achieve this, life must have had mechanisms for the selection and replication of complex sequences. Contrary to today's biology however, the mechanism must have been simple and driven by physical non-equilibria. A local thermal gradient across a microfluidic pore can overcome the tyranny of the shortest by autonomously driving length selection and accumulation of DNA, thereby fostering more complex sequences. This can lead to hybridization and the formation of hydrogels. We use the sequence dependence and specificity of Watson-Crick base pairing and hydrogel formation to find a physical selection mechanism for DNA sequences. Hybridization and hydrogel formation can break the symmetry in sequence space and select mutually interacting and thus potentially functional sequences. Experimentally, we start with a pool of random ssDNA libraries and quantify the bias of hydrogelation by high throughput sequencing. With increasing selection pressure and modifying the initial library, we will narrow down the pool of functional sequences and see possible replicating function emerge.

BP 6.16 Mon 17:30 Poster B2

Effects of increased electrostatic repulsion between head groups of cardiolipin monolayers — Renko Kensbock, •Heiko Ahrens, and Christiane A. Helm — Institute of Physics, University of Greifswald, Germany

Cardiolipin is an anionic lipid, consisting of four hydrophobic alkyl chains and a hydrophilic head, which carries up to two charges. We investigate tetramyristoyl cardiolipin (TMCL) monolayers at the air-water interface with isotherms, grazing incidence diffraction and model calculations. TMCL undergoes a fluid (LE) to gel (LC) phase transition at a transition surface pressure π_c(T). By tuning the subphase composition, the surface charge density is varied. We verify the linear temperature dependence of π_c(T). With increasing surface charge density, the tilt of the alkyl chains in the LC phase increases. Furthermore, we find a correlation between the slope ($d\pi_c/dT$) and the tilt of the alkyl chains in the gel phase. We compare the obtained TMCL monolayer results with other lipids from literature.

BP 6.17 Mon 17:30 Poster B2

Tailor-made single electrode device to study human stem cell derived neurons — •Jeremy Teuber — Center for Hybrid Nanostructures

Studying the electrophysiological properties of cells is a basic requirement for understanding the nature of electrical impulses between single neurons. We have designed and fabricated tailor-made single electrode devices on silicon wafers for electrophysiological measurements of individual cells. The bilayer electrode system on a silicon wafer was prepared by UV laser photolithography and chemical vapor deposition. Here, the electrode consists of a conducting gold layer where the electrical supply lines are covered with an insulating layer of silicon dioxide. Alignment and material deposition of the custom-made device were examined by light microscopy as well as scanning electron microscopy. Stable and robust bonding of the individual material layers ensures that the device endures a cleaning procedure with trypsin and EDTA to enable multiple usability of the device. A 3D-printed ring glued with PDMS to the wafer is used to form a defined volume, in which the neurons are confined during the cultivation forming neural networks on the electrode. In detail, human stem cells are stimulated by using glutamate or patch clamping and the generation of the action potential is measured by the substrate electrode. The devices are further optimized with respect to geometry and materials to obtain increased signal-to-noise ratios. This device offers the opportunity to gain deep understanding of the characteristics of stem cells derived neurons.

BP 6.18 Mon 17:30 Poster B2

C. Elegans Nematodes Deform like Elastic Rods. — •Octavio Albarran[1], Peter Weist[1], Eugenia Butkevich[1], Renata Garces[1], and Christoph Schmidt[1,2] — [1]Drittes Physikalisches Institut - Biophysik Friedrich-Hund-Platz 1 37077 Goettingen — [2]Department of Physics, Duke University, Durham, NC 27708, USA.

To perform undulatory locomotion, C. elegans nematodes generate forces with their body-wall muscles acting on the surrounding environment and against their own body deformation resistance. The knowledge of the body rigidity is crucial to understand the dynamic functions of the worm.

It has been hypothesized that the worm kinematics can be understood in terms of viscoleastic beam theory. However, to date, mechanical studies in the large deformation regime, typical of native undulatory locomotion, are lacking. We here present a micro-needle-based experiment imposing large strains. Living worms were kept straight by clamping their extremities onto agar plates. We laterally displaced the centers of worms with a glass cantilever of known spring constant. To separate passive responses from muscle activity, we varied the contraction relaxation state of the muscles using pharmacological interference. We directly probed the beam theory through the analysis of the loading curves. Interestingly, we found that linear constitutive relations (without viscous effects) are sufficient to explain the experimental data. We provide a synthesis of the typical range of magnitudes of effective elastic modulus for different muscles states of the worms.

BP 6.19 Mon 17:30 Poster B2

Adsorption of Bovine Serum Albumin on Glass Surfaces observed by X-ray Reflectometry — •Annemarie Pfnür[1], Michail Goldes[1], Sarah Höhn[2], Aldo Roberto Boccaccini[2], and Tobias Unruh[1] — [1]Institute of Crystallography and Structural Physics, Friedrich-Alexander-Universität Erlangen- Nürnberg (FAU), Staudtstr. 3, 91058 Erlangen, Germany — [2]Department of Materials Science and Engineering, Institute for Biomaterials, Friedrich-Alexander-Universität Erlangen- Nürnberg (FAU), Cauerstr. 6, 91058 Erlangen, Germany

Bioactive glass (e.g. 45S5) is used since more than 30 years in bone and dental implants. In contact with liquids soluble silica, calcium phosphate, and sodium ions are released from the surface and a crystalline hydroxyapatite layer on the glass surface is formed which can bond to bone tissue. A basic understanding of the medical compatibility on a molecular level has, however, not been achieved yet.

Thus, we present first X-Ray Reflectivity (XRR) data on protein adsorption on glasses which is intended to mimic the very first step of glass interaction with body fluid and cells after implantation. We were able to detect protein monolayers and determine the thickness and roughness of the protein layer on the angstrom scale. Furthermore, we are sensitive to aging effects of the glass surface, e.g. glass corrosion, which occur when the glass is immersed in water or buffer. The results from bio glass is compared to soda lime and borosilicate glass.

BP 6.20 Mon 17:30 Poster B2

Towards a more realistic model of adhesion clusters under force — •Andrea Bräutigam, Gerhard Gompper, and Benedikt

Sabass — Theoretical Soft Matter and Biophysics, Institute of Complex Systems and Institute of Advanced Simulation, Forschungszentrum Jülich, Germany

Adhesion domains play a crucial role in many cellular processes such as cell migration or communication with surrounding tissue. These usually localized contacts to the extracellular environment are composed of organized aggregates of proteins that form a dynamic cluster sensitive to internal and external signals. Especially under the influence of force, adhesion domains show a rich behavior affecting cluster size, constitution and lifetime. Although the complex system of adhesion sites and their response to force are not fully understood, they apparently have high importance for cellular integrity and mechanical sensing.

Here we present a minimal model for an adhesion cluster of parallel bonds under force. The state of the cluster evolves stochastically through (un)binding events and conformational changes of single bonds until the system eventually ruptures. In our analysis, cluster dynamics is described by an absorbing Markov Process. We derive a mean field approximation which reduces the complexity of the system significantly and allows further studies. In addition, statistically correct trajectories of adhesion clusters with different sizes are generated *in silico*. The approximative system and simulation results show good agreement and provide insight into force-dependent characteristics, such as cluster size and lifetime.

BP 6.21 Mon 17:30 Poster B2

Dynamic patterns of the plant growth regulator auxin — •Joao Ramos and Karen Alim — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Auxin is a plant hormone that promotes growth by altering the mechanical properties of the cell wall, ubiquitously acting throughout plant development. Specific morphologies are tied to patterns of auxin concentration and flow emerging from carrier mediated cell-cell auxin transport. In particular, efflux carrier proteins of the PIN family are the main players in directing auxin flow. Recent data suggest that PIN polarity and mechanical stress may be causally linked. In order to explore the interplay between auxin-mediated cell wall loosening, growth and mechanically-regulated PIN polarity, we have developed a mechanical vertex model coupled to a compartment model for auxin transport. We apply our model to the developmental process of lateral root formation (LRF), which offers empirical accessibility as well as a wide range of developmental patterns accompanied by a wide variety of impactful mechanical cues. Here, we can explain auxin flows down-the-gradient of auxin concentration, present in fountain-like patterns during LRF, by the competition between stress or stiffness gradients and PIN expression. During early LRF, we can explain auxin accumulation and founder cell swelling through differential turgor pressure. Independent of a specific developmental process, we show that mechanical relaxation of cell geometry amplifies mechanically-mediated PIN polarity.

BP 6.22 Mon 17:30 Poster B2

Robust increase in supply by vessel dilation in globally coupled microvasculature — •Felix J. Meigel[1], Peter Cha[2], Michael P. Brenner[2], and Karen Alim[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen, Germany — [2]Harvard University, Cambridge, MA, U.S.A.

Neuronal activity induces changes in blood flow by locally dilating vessels in the brain microvasculature. How can the local dilation of a single vessel increase flow-based metabolite supply given that flows are globally coupled within microvasculature? Solving the supply dynamics for a microvasculature excerpt, we find one parameter regime to dominate. This regime allows for robust increase in supply independent of the exact position in the network, which we explain analytically. We show how the local coupling of supply in vessels promotes spatial clustering in increased supply by dilation.

BP 6.23 Mon 17:30 Poster B2

Functionalized lipid bilayers as a platform to study cell adhesion — •Anastasia Svetlova, Vanessa Maybeck, Jana Ellieroth, Frano Milos, and Andreas Offenhäusser — Institute of Bioelectronics (ICS-8), Forschungszentrum Juelich, Wilhelm-Johnen Straße, 52425 Juelich, Germany

Artificial lipid bilayer is the closest possible model for the cell membrane. Despite that, current methods of lipid bilayer assembly and functionalization do not provide a satisfactory mimic of cell-cell contact due to the inability to recreate an asymmetrical multicomponent system. In the current work, a method to produce an integrated solid-supported lipid bilayer combining natural extracts from cell membranes and artificially made lipid vesicles is proposed. This simple method allows delivery of transmembrane proteins and components of the extracellular matrix into the substrate. Physical properties such as lateral diffusion coefficient of lipids in the bilayer can be controlled by adjusting the ratio of components in the substrate. Biocompatibility of the composite natural/artificial lipid bilayers is evaluated by their interactions with the cardiomyocyte-like HL-1 cell line. Compared to fully artificial mixes, composite bilayers allow cells to adhere and develop a morphologically more normal cytoskeleton.

BP 6.24 Mon 17:30 Poster B2

Foraging behaviour of *Physarum polycephalum* — •Lisa Schick, Mirna Kramer, and Karen Alim — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Foraging behaviour of animals is generally described as optimized for maximal energy uptake per time spend foraging within optimal foraging theory. Food sources often occur as food patches, so that foraging becomes a balance between time spent for exploration and time spent for patch exploitation leading to the question at which point a patch should be abandoned. Foraging behaviour in a patchy habitat can also be observed in unicellular but spatially extended organisms like *Physarum polycephalum*. However, it is unclear which foraging strategy the large and adaptive network-like morphology allows for. The plasmodial network of *P. polycephalum* adapts its morphology in the process of foraging by mass transport. Recent observations show that on encounter of a food patch, depending on body size, the whole body is relocated for exploitation. We here study the morphological changes as a function of network size and nutritional state by introducing a model for the exploration and exploitation phases in *P. polycephalum*. We estimate the energy uptake from our foraging observations in order to obtain rules for the foraging behaviour.

BP 6.25 Mon 17:30 Poster B2

Roughness and wettability assessment of substrates with regard to cell adhesion — •Paul Lühe, Issam Assi, Christian Völkner, Regina Lange, Ingo Barke, and Sylvia Speller — Institute of Physics, University of Rostock, 18051 Rostock

Cell adhesion and spreading on surfaces are crucial properties for medical applications, e.g. for biocompatibility of human implants. Important parameters frequently considered in this context are wettability and roughness, both being dependent on geometric and chemical details of the surface, including the history of preparation and treatment. Common techniques for surface conditioning are rinsing and ozone cleaning. In this study we assess the effect of treatment and exposure time in ambient conditions on roughness and wettability of glass with and without transparent Au layers and PDMS surfaces by means of contact angle measurement and atomic force microscopy. The results are discussed in view of expected cell adhesion and spreading properties.

BP 6.26 Mon 17:30 Poster B2

To stick or not to stick - interfacial forces and biological mechanisms regulating microalgae adhesion — •Alexandros Fragkopoulos, Christian Kreis, Anaelle Chretien, Alice Grangier, Christine Linne, and Oliver Bäumchen — Max Planck Institute for Dynamics and Self-Organization, D-37077 Göttingen, Germany

For many microorganisms, attaching to a substrate is of paramount importance since it allows for cells to stay at nutrient-rich environments or form biofilms. In particular, a population of microbes that grows in porous environments is in constant interactions with interfaces. Here we present a study on the adhesion and surface colonization of *C. reinhardtii*, a unicellular biflagellated microalga. Using micropipette force spectroscopy experiments, we can measure the adhesion force on a single-cell level [1]. We show that its flagella-mediated adhesion to surfaces can be switched on and off by controlling the light conditions [2]. We exploit this behavior to study the cells on a population level by analyzing the Langmuir-type adsorption-desorption dynamics of cells on solid interfaces as they switch between the planktonic (freely swimming) and the surface-associated state. Using tailored model substrates, we reveal the intermolecular forces governing the adhesion of Chlamydomonas to surfaces. Finally, we use both methods to study the effect of the cell mating type, growth medium, and life stage on the adhesion.

[1] M. Backholm, O. Bäumchen, *Nat. Protoc.*, in press (2018)
[2] C.T. Kreis et al., *Nat. Phys.*, **14**, 45 (2018).

BP 6.27 Mon 17:30 Poster B2

Fluid flow control on morphological changes — •Noah Ziethen and Karen Alim — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

The morphology of biological transport networks is often regarded as a result of optimization under a given demand. As demands may change rapidly in life, biological flow networks continuously adapt. One particular way of adaptation is the simplification of the network by erosion of specific vessels (pruning). Interestingly, pruning controlled by local flow shear rate is equivalent to global optimization towards minimal dissipation at a fixed network volume.

Here, the model organism *Physarum polycephalum* allows to directly test causality between flow shear rate change and vessel pruning. *P. polycephalum* forms a network of connected tubes exhibiting a complex oscillatory shuttle streaming inside them. We image and quantify the time evolution of single vessel junctions in *P. polycephalum*. We extract the vessel diameters evolution and the corresponding flow field using particle image velocimetry (PIV). We determine the flow profiles for different vessel thicknesses which show surprisingly good agreement with Poiseuille flow. The flow profiles are used to calculate the local shear rate acting on the tube walls. Additionally, we measured the flow rate, the maximum and the variation of the flow velocity. All these above-mentioned quantities are then correlated with the event of pruning.

BP 6.28 Mon 17:30 Poster B2

Memory capacity of a flow network — •Komal Bhattacharyya and Karen Alim — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

The slime mould *Physarum polycephalum* is a very simple unicellular but seemingly intelligent organism with a network-like body. Its complex behaviour requires the ability to propagate, store and process information. Recently, it has been shown that *Physarum* propagates information about stimuli with the fluid flows throughout its network. And most inspiringly, *Physarum* was observed to adapt its networks tube radii network-wide in response to stimuli, reaching a steady-state as a long term response to the applied stimuli, keeping a memory of the stimuli in its network morphology. Inspired by this observation we here investigate the capacity to store information about previous stimuli in the morphology of an adaptive flow network. We model the organism as a flow network whose radii can change when optimising the network to have least energy dissipation. We observe how the system reacts to localised changes and the timescale of its responses to applied stimuli by numerical simulation. Through theoretical understanding we aim to pin-point to the information storing and processing capabilities of adaptive flow networks in general and *Physarum* networks specifically.

BP 6.29 Mon 17:30 Poster B2

Application of 3D Lithography — •Jana Kredl[1], Christian Denker[1], Cornelius Fendler[2], Julia Bethune[4], Nina Meyer[1], Tobias Tubandt[1], Finn-F. Lietzow[1], Neha Jha[1], Chris Badenhorst[3], Alena Rong[5], Jakob Walowski[1], Mark Doerr[3], Raghvendra Plankar[4], Mihaela Delcea[5], Uwe T. Bornscheuer[3], Robert Blick[2], Swadhin Mandal[6], and Markus Münzenberg[1] — [1]Institute of Physics, University Greifswald, Germany — [2]Institute of Nanostructure- and Solid State Physics, University Hamburg, Germany — [3]Institute of Biochemistry, University Greifswald, Germany — [4]Institute of Immunology and Transfusion Medicine, University Medicine Greifswald, Germany — [5]Centre for Innovation Competence - Humoral Immune Reactions in Cardiovascular Diseases, University Greifswald, Germany — [6]Indian Institute of Science Education and Research Kolkata, India

3D 2-Photon-Lithography, originally developed for 3D photonic crystals, opens a wide range of new possible applications in many fields, e.g. life sciences, micro-optics and mechanics [1]. We will present our recent applications of 3D 2-Photon-Lithography and show 3D evaporation masks for in-situ device fabrication using different deposition angles, infra-red laser light focusing lenses directly fabricated on optical fibers, tunnel structures for guiding growth of neurons, pillars for investigation of cell mechanics and master-mold fabrication for Polydimethylsiloxane (PDMS) micro-fluidic channels.
[1] J. K. Hohmann et al., Adv. Optical Mater. 3 (2015) 1488

BP 6.30 Mon 17:30 Poster B2

Influence of extracellular vimentin on cell migration — •Divyendu Goud Thalla[1] and Franziska Lautenschläger[1,2] — [1]Cytoskeletal Fibers, INM-Leibniz-Institut für Neue Materialien gGmbH, Saarbrücken,Germany — [2]Experimental Physics, Saarland University, Saarbrücken, Germany

Vimentin is a cytoskeletal protein of the family of intermediate filaments which plays a role in cell migration, adhesion and signaling. Apart from its presence in the cytoplasm, it is also found in the extracellular spaces around cells. Secreted vimentin controls inflammation by reducing the neutrophil infiltration, helps in bacterial elimination and consequently triggers the oxidative metabolites in activated macrophages.It promotes axonal growth in astrocytes by activating IGF1 receptors in the same signaling pathway as IGF1. The IGF1/IGF1-R pathway plays a significant role in general cellular functions such as cell migration, proliferation, adhesion and invasion. In this study, we demonstrate the functional similarities of extracellular vimentin and IGF1 in context with these cellular functions. Using a MTT proliferation assay, we show that extracellular vimentin increases the proliferation rate in MCF-7 cells. Furthermore, we carried out wound healing assays suggesting that extracellular vimentin promotes MCF-7 cell migration. In future, we plan to investigate the role of extracellular vimentin in adhesion and invasion to show if it has a similar role in these cellular functions. Consequently, it might be useful for altering and stimulating these cellular functions which would open up the possibility for treating various disease conditions.

BP 6.31 Mon 17:30 Poster B2

The nanomorphology of osteoblasts with regard to adhesion parameters investigated by Scanning Ion Conductance Microscopy — •Christian Völkner[1], Regina Lange[1], Martina Grüning[2], Ingo Barke[1], Barbara Nebe[2], and Sylvia Speller[1] — [1]University of Rostock, Institute of Physics, 18051 Rostock — [2]University Medical Center Rostock, Dept. of Cell Biology, 18057 Rostock

Our aim is to elucidate the behavior of osteoblasts (MG-63) and mechanisms of cell adhesion on material surfaces. This we address by investigating the nanomorphology of the cells on various substrate surfaces by means of Scanning Ion Conductance Microscopy (SICM). The cell membrane surfaces exhibit protrusions with leave-like shapes. We attribute these features to so called ruffles [1]. They were found to be very mobile on the cell surface, dominating the signal of membrane height fluctuations. Latter may be developed as a parameter to monitor cell activity. We also focus on the rim of the cells, which exhibits heights between 100 nm up to micrometers with respect to the underlying substrate surface with its own physico-chemical characteristic. This implies large gaps between the cell and the substrate in the periphery, indicating locally varying adhesion clefts.
[1] Chhabra et al., Nature Cell Biol. 9, 1110 (2007)

BP 6.32 Mon 17:30 Poster B2

Influence of substrate elasticity and geometry on cell migration — •Stefanie Haberlandt and Florian Rehfeldt — Georg-August-University Goettingen, Third Institute of Physics - Biophysics, Friedrich-Hund-Platz 1, 37077 Goettingen, Germany

Cell migration plays an important role in many processes which are vital for the development and homeostasis of multi-cellular organisms. It is also a crucial aspect in the development of several diseases such as cancer. Since the various tissues in our body differ significantly with respect to mechanical properties, biochemical composition, and topography, a systematic investigation of how these micro-environments impact migration is essential. This will lead to a better understanding of e.g. invasive cancer cells during tumor metastasis. Here, we experimentally observe and analyze unconfined 2D migration of NIH-3T3 fibroblasts and hMSCs on collagen-I coated polyacrylamide (PA) gels of different Young's moduli E. Using a micro-patterning approach we also created distinctly confined areas on the elastic gels to analyze the impact of geometry on migration. Since patterning on soft gels is challenging, we compared different approaches and present data from migration analysis that depends on cell type, Young's modulus E, and geometry.

BP 6.33 Mon 17:30 Poster B2

Scaling Emergency Response of *Physarum polycephalum*: On the verge of death — •Jonghyun Lee, Adrian Fessel, and Hans-Günther Döbereiner — Institut für Biophysik, Universität Bremen

Physarum polycephalum is a unique unicellular organism that displays

a wide array of behavioural patterns and structures. Some of these behaviours, such as learning or having a memory, were previously thought to be associated with more evolved organisms. We explore the capabilities of this organism further, by fragmenting it into microscopic particles called microplasmodia.

Normally, microplasmodia fuse together to form one giant network, previously described as a percolation transition [1]. However, under starvation, these microplasmodia do not reconstitute as one body, but as multiple mesoplasmodia, referred to as satellites, that move away from their original spot [2]. We investigated how the initial conditions influence the outcome of the growth pattern, via maximum search area hypothesis based on optimal foraging theory.

We found that the initial distribution of microplasmodia is the main factor of satellite formation, and the scaling relationship can be derived to describe the number and the size of these fragments. We further refine the model by accounting for collisions and probabilities of fusion during satellite formation, which agrees well with experimental results. Therefore, our unicellular organism on the verge of death maximizes its search area.

[1] Fessel, A. et al. (2012), Physical Review Letters 109, 078103. [2] Lee, J. et al. (2018), Journal of Physics D: Applied Physics 51, 244002

BP 6.34 Mon 17:30 Poster B2

Comparison of mechanical properties of cells using different cantilevers as probe tips for atomic force microscopy — •Florian Frederick Stuckmann, Hsiao-Ching Tsai, and Mathias Getzlaff — Institut für Angewandte Physik, Heinrich-Heine-Universität, Düsseldorf, Deutschland

The elasticity is one of the most important characteristics of the cell. To determine concerning deviations caused by pathologies, atomic force microscopy with a precise cantilever represents a powerful tool.

This scientific work analyzed mechanical properties of fibroblasts. Using a spherical or a pyramidal cantilever the cell elasticity of the fibroblasts can be determined. After the application of the AFM-Mode 'Force-Mapping' and the following data process, values of the Young Modulus of the fibroblasts can be obtained, which are illustrated in a map. Hence, the elasticity of typical areas such as the cell perimeter or above the nucleus can be quantified.

As a consequence of the tip shape, performance differences between the two cantilever types can be observed when working with biological samples. Because elasticity values cannot be determined at every point in case of the pyramidal cantilever, the sharp tip seems to damage the cell membrane.

BP 6.35 Mon 17:30 Poster B2

Epithelial-Mesenchymal Transition (EMT)-induced changes of cortical contractility and stiffness in breast epithelial cells — •Kamran Hosseini and Elisabeth Fischer-Friedrich — Biotechnology center of TU Dresden (Biotec), Dresden, Germany

Cancer cells have been reported to show a softer phenotype. At the same time, it has been speculated that invasive cancer cells are particularly contractile. Epithelial mesenchymal transition (EMT) has been previously identified as a key process in cancer progression and metastasis, suggesting that EMT reduces cell stiffness and enhances cell contractility. To test this hypothesis, we probed breast epithelial cells mechanically before and after chemically induced epithelial mesenchymal transition (EMT). We uniaxially compressed isolated suspended cells in a parallel plate confinement assay using an atomic force microscope in conjunction with a wedged cantilever. In this way, we measured cortical contractility and cortical stiffness. We find that cell stiffness is decreasing jointly with cortical contractility through EMT in suspended cells.

BP 6.36 Mon 17:30 Poster B2

Correlation of force generation and actin structure in blood platelets — •Anna Zelena[1], Dimitri Probst[2], Johannes Blumberg[2], Ulrich S. Schwarz[2], and Sarah Köster[1] — [1]Institute for X-ray Physics, Georg-August-University Göttingen, Göttingen, Germany — [2]Institute for Theoretical Physics, Heidelberg University, Heidelberg, Germany

Human blood platelets are non-nucleated fragments of larger cells (*megacaryocytes*), which are important for blood clotting. The hemostatic function of platelets is directly linked to their mechanics and cytoskeletal morphology. However, the exact mechanism of spreading and contraction remains elusive. In our study, we focus on the investigation of single blood platelets *in vitro* by traction force microscopy (TFM) and direct imaging using an SiR actin probe. By analysis of bead displacements inside the polyacrylamid (PAA) gels, which serve as substrates for the platelets, we are able to correlate the force generation with the actin reoganization in a time resolved manner. The force maps we obtain show a hot spot distribution, typically in spindle-like, triangular or circular shape, that we correlate with actin structures inside spreading blood platelets. In addition, we investigate the actin structures of platelets on PAA gels with different elasticity in the physiological range (1-100 kPa) and their behavior in presence of micropatterned fibrinogen surfaces.

BP 6.37 Mon 17:30 Poster B2

Numerical Investigation of Cell Deformation during Bioprinting Processes — •Sebastian Müller and Stephan Gekle — University of Bayreuth

Cell viability and functionality during bioprinting processes strongly depend on the deformations that cells experience during printing. These, in turn, result from the mechanical stresses caused by the surrounding fluid motion.

Using the multiple-relaxation-time Lattice Boltzmann Method implemented in the software package ESPResSo, which we extended with shear thinning viscosity models and a neo-Hookean cell model, we investigate the deformation of cells during the printing process qualitatively in dependence of the shear thinning properties and the printing parameters.

BP 6.38 Mon 17:30 Poster B2

Acoustic wave irradiation of cancer cells — •Lena Fastenrath[1], Maja Strugacevac[1], Tobias Löffler[1], Constanze Wiek[2], Julia Kristin[2], Jörg Schipper[2], and Mathias Getzlaff[1] — [1]Heinrich-Heine-Universität Düsseldorf, Institute of Applied Physics, Universitätsstr. 1, 40225 Düsseldorf, Germany — [2]Düsseldorf University Hospital, Department of Otorhinolaryngology, Moorenstrasse 5, 40225 Düsseldorf, Germany

Our group is developing new, alternative, cell-selective treatment strategies for squamous cell carcinoma cells of the head-neck area. This therapy is based on the different mechanical properties of oral keratinocytes and cancer cells.

Squamous cell carcinoma cells were exposed in vitro to sound waves exhibiting frequencies between 0.5 kHz and 10.0 kHz. For those frequencies that have lead to the strongest cell reaction we varied input voltage and the distance between the cells and the sound probe.

The reaction and the change of areal extent of the cells were observed under a fluorescence confocal laser scanning microscope. Our latest results will be presented and discussed.

BP 6.39 Mon 17:30 Poster B2

Size-dependent forces during phagosomal transport — Simon Wieland[1,2], •David Gitschier[1,2], Magdalena Haaf[1], Solange Hoffbauer[1], and Holger Kress[1] — [1]Biological Physics Group, Department of Physics, University of Bayreuth, Germany — [2]Joint first authors

The intracellular transport of organelles plays an important role for a large variety of cellular processes, such as exocytosis and endocytosis. It is well established that the transport of organelles is biochemically regulated. However recently, it was shown that also the size of the organelles has a strong influence on the transport. In macrophages it was found that large phagosomes are transported very persistently towards the nucleus whereas small phagosomes show a highly irregular Motion[1]. To unravel the molecular causes of this behavior, we investigated the intracellular transport forces of phagosomes as a function of their size by using magnetic tweezers. We found that transport forces increase monotonically for organelle sizes up to four micrometers. The scaling of the transport forces with the organelle sizes together with an identification of the types and numbers of involved motors can lead to a more fundamental understanding of intracellular transport and the cooperation of molecular motors.

[1] S. Keller, K. Berghoff, H. Kress, Phagosomal transport depends strongly on phagosome size. Scientific Reports, 7 (2017), 17068

BP 6.40 Mon 17:30 Poster B2

CAOS - How to Stretch Adherent Cells — •Tobias Neckernuss, Daniel Geiger, Jonas Pfeil, and Othmar Marti — Institute of Experimental Physics, Ulm University

We demonstrate a new method to stretch adherent cells with light. This has the advantage that no interaction with a probe is necessary to determine the mechanical properties of cells. Additionally not only

point like forces can be applied, but the cell is stretched over its whole membrane surface. We show measurements on 3T3 cells as cultured and compare them to measurements taken on 3T3 cells treated with latrunculin. The deformation data is fitted to viscoelastic models consisting of networks of springs and dashpods. With the Akaike singular information criterion the best models are selected. Results confirm that the new technique works well an delivers results in agreement with literature. Additionally, by investigation of the behavior of individual parameters conclusions about different parts of the cytoskeleton can be drawn. In addition, the new technique proved to be more sensitive and precise than the well established technique of passive microrheology.

BP 6.41 Mon 17:30 Poster B2

Probing cellular resolution limits during phagocytosis — •Manuel Eisentraut, Adal Sabri, and Holger Kress — Biological Physics Group, Department of Physics, University of Bayreuth, Germany

Phagocytosis can be initiated by the binding of an immunoglobulin G (IgG)-opsonized particle to Fcγ-receptors in the cell membrane. While the molecular components of the underlying signaling cascades are well known, it is unclear how fast and how far the corresponding signals propagate in the cell. To address these issues, we investigate the spatial spreading of phagocytic signaling by measuring how well cells can resolve whether one or two particles are attached to the cell membrane. In our experiments, we attach pairs of polystyrene beads opsonized with IgG to single macrophages. The use of holographic optical tweezers allows us to precisely control the bead-to-bead distance during the attachment. The subsequent uptake into one joint or in two separate phagosomes is distinguished by analyzing the intracellular particle trajectories after the uptake.

For medium-sized phagosomes with a diameter of two micrometers, we found that the probability for joint uptake is very high for small distances and very low for large distances, with a transition between these regimes at distances of several hundreds of nanometers. Further studies with larger and smaller target beads will allow us to determine whether this resolution limit is constant or whether it scales with the target size, which will provide quantitative insights into the spatial spreading of signaling during phagocytosis.

BP 6.42 Mon 17:30 Poster B2

Traction Force Microscopy during Phagocytosis — •Wolfgang Gross and Holger Kress — Biological Physics Group, Department of Physics, University of Bayreuth, Bayreuth, Germany

In the process of phagocytosis, cells internalize objects like bacteria and dead cells that have a size of several micrometers, thus being a main function of innate immunity. After the detection of foreign particles, the membrane starts to wrap around the phagocytic target. This so-called phagocytic cup is mechanically supported by the polymerization of actin filaments in combination with myosin motors. Even though the main molecular players have been identified already, there is only few quantitative data describing the dynamics of the major regulators.

To investigate the uptake dynamics we use immunoglobulin G (IgG) coated polystyrene particles with a diameter of 10 micrometers as a model system. Using a combination of traction force microscopy (TFM) and holographic optical tweezers, we are able to measure cellular forces during phagocytosis in a spatially and temporally resolved manner. As a substrate, we use soft polyacrylamide films with a thickness of a few tens of micrometres which we coat with fibronectin to mediate cell adhesion. TFM allowed us to quantify the forces, which J774 macrophages exert during adhesion and phagocytic uptake. Preliminary data show the distribution of contractile forces in the direct vicinity of the phagocytic target. We anticipate our results to pave the way for a more quantitative understanding of phagocytosis and thus, enable the development of new models for this process.

BP 6.43 Mon 17:30 Poster B2

Rayleigh-Plateau-like instability of an active cylindrical cell membrane — •Katharina Grässel, Christian Bächer, and Stephan Gekle — Universität Bayreuth, Bayreuth, Deutschland

A free liquid jet undergoes a pearling instability, named after Rayleigh and Plateau, that is triggered by the surface tension of the fluid. To account for a biological membrane consisting of the cell cortex underlying a lipid bilayer, the classical model of the Rayleigh-Plateau instability is extended to include bending elasticity of the bilayer as well as anisotropic surface tension, modelling contractile active stresses in the cortex. These extensions lead to alteration of the wavelength of the instability and are confirmed by Lattice-Boltzmann simulations.

BP 6.44 Mon 17:30 Poster B2

First evidence of cellular uptake of environmentally relevant microplastic particles — •Anja Ramsperger[1,2,4], Bangalore Vinay Kumar[1,4], Wolfgang Gross[2,4], Holger Schmalz[3,4], Holger Kress[2,4], and Christian Laforsch[1,4] — [1]Animal Ecology I and BayCEER — [2]Biological Physics Group — [3]Macromolecular Chemistry II and BPI — [4]University of Bayreuth, Germany

Research efforts on microplastic (MP) pollution is strongly increasing during the last 15 years. Plastic introduced to the environment undergoes processes of degradation and disintegrates to MP. Furthermore, microbes attach to MP surfaces and, together with biomolecules, form an ecocorona that can enhance the ingestion of MP by organisms. Once ingested there is evidence that MP can harm organisms for example by translocating into tissue causing e.g. inflammatory responses. The processes involved in the translocation of MP into tissue are not known and to our knowledge a process for cellular uptake of environmentally relevant MP was not described to date. Therefore, we investigated the cellular uptake of MP and show that MP from environmental media gets internalized by murine macrophages significantly more often than control MP. To unravel which surface properties might trigger internalization into cells, we are currently analyzing the composition of the ecocorona on MP by using SEM and micro-Raman spectroscopy. A quantification and characterization of the internalization of environmentally relevant MP by cells will likely be an important step for understanding the potential subsequent translocation into tissue and inflammatory responses which can harm the whole organism.

BP 6.45 Mon 17:30 Poster B2

Cross-talk between cell shape and state during cell fate transitions — •Wolfram Pönisch[1], Irene Aspalter[1], Agathe Chaigne[1], and Ewa Paluch[1,2] — [1]MRC Laboratory for Molecular Biology, University College London, London, UK — [2]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, UK

The development of an organism is characterized by a series of cellular fate transitions where cells acquire increasingly specialized phenotypes. Such fate transitions are often accompanied by cellular shape changes and there are strong indications of a coupling between cell shape and fate. Here, we present a pipeline to quantify and analyze cell shapes as cells undergo fate transitions. We will present how the morphometric features of cell shapes can be quantified and how the high dimensional dataset can be analyzed with the help of dimensional reduction methods such as PCA and tSNE. To identify clusters of cells and classify cells based on those clusters, we use a variety of machine learning algorithms. To apply our analysis pipeline, we study the coupling between cell shape and fate during the exit from naïve pluripotency in mouse embryonic stem cells. We find that cells can be classified into two unambiguously distinguishable clusters: While cells possess a spherical shape before exiting naïve pluripotency, they spread on a substrate after exiting. Furthermore, cell shape change appears to be essential for the associated fate change.

BP 6.46 Mon 17:30 Poster B2

Rheology of hydrogels based on chemically modified hyaluronic acid — •Martin Schilling and Florian Rehfeldt — Third Institute of Physics - Biophysics, Georg-August-University, Göttingen, Germany

Many aspects of cell behavior are influenced by the mechanical properties of their microenvironment. To mimic the various elastic Young's moduli E of different in vivo environments of cells, it is necessary to design and mechanically characterize hydrogels for cell culture that are biocompatible and allow for a tunable elasticity.

Hyaluronic acid (HA), a polysaccharide consisting of disaccharide units, was chosen as base for the hydrogel system as it is biocompatible and not toxic for cells, thus allowing for 3D encapsulation.

Native HA hydrogels exhibit a visco-elasticity at the lower end of the physiologically relevant stiffness range. Here, we show that by chemical modification and subsequent covalent cross-linking, we can cover the required range from 0.1 kPa to 100 kPa. Additionally, altering the degree of modification of HA allows distinct and independent tuning of Young's modulus and biochemical recognition of HA by cells. Mixtures of both high and low modified HA are examined to combine both properties. The gelation kinetics of the resulting hydrogels are investigated by rheology using oscillatory shear tests both in the low and high strain (LAOS) regime.

BP 6.47 Mon 17:30 Poster B2

Traction force microscopy of HAELVI cells on silicone gel substrate — •Susan Tavakoli[1], Kay-E. Gottschalk[1], Manfred Frick[2], Kathrin Diem[2], Eric Dufresne[3], and Kathryn Anne Rosowski[3] — [1]Institute for Experimental Physics, Ulm University, Germany — [2]Institute of General Physiology, Ulm University, Germany — [3]Soft and living Materials, ETH Zürich, Switzerland

Cells interact with their environment in different ways, chemically and mechanically. Through various interactions, cells exert forces on their substrate or adjacent cells. Quantifying these forces under different environmental changes have been the subject of many studies. The method of measuring these forces - known as Traction Force Microscopy, calculates the forces based on the deformation made by cell on a highly flexible substrate that is measurable by tracking the displacement of fluorescent beads attached to the surface. We make the substrates from a biocompatible polymer gel known as Polydimethylsiloxane (PDSM) that has a very low stiffness and its transparency facilitates microscopy. Briefly, a glass coverslip is covered with a uniform layer of the gel using spin-coating technique then a layer of fluorescent beads covers the surface of the gel. We use a matlab code that calculates the forces using the geometry and mechanical characteristics of the gel and the beads displacements to quantify traction forces of HAELVI cells under normal condition as well as treatment with Blebbistatin. Our aim will be to combine this method with a stretcher device, simulating the breathing function to study lung epithelial cells.

BP 6.48 Mon 17:30 Poster B2

The effect of reactive oxygen species on the molecular and mechanical phenotype of C6 glioma cells — •Yesaswini Komaragiri[1], Doreen Biedenweg[2], Ricardo H. Pires[1], and Oliver Otto[1] — [1]ZIK-HIKE, Universität Greifswald, Greifswald, Germany — [2]Universitätsmedizin Greifswald, Greifswald, Germany

Reactive oxygen species (ROS) are one of the main sources of oxidative stress which are associated with important alterations in cell physiology. Mechanical properties have long been established as a label-free biomarker but their interplay with alternating levels of ROS has not been fully investigated. This study focusses on understanding the impact of oxidative stress on the mechanical properties of immortalized rat brain C6 glioma cells. In an in vitro assay, mitochondrial superoxide was generated by exposing cells to varying concentrations of hydrogen peroxide. Using real-time fluorescence deformability cytometry, we link for the first time the molecular phenotype of ROS using MitoSOX-red as a fluorescent marker to changes in the mechanical phenotype as a label-free biomarker. We show that for micro-molar concentrations of H2O2, the elastic Young's modulus of the cells increases, which is in contrast to previous studies focusing on concentrations in the millimolar range.

BP 6.49 Mon 17:30 Poster B2

A muscle cell seen as active matter: Heterogeneities and dynamic instabilities in sarcomere contraction of cardiomyocytes — •Daniel Härtter[1], Wolfram-Hubertus Zimmermann[2], and Christoph F. Schmidt[1,3] — [1]Drittes Physikalisches Institut - Biophysik, Georg-August-Universität Göttingen — [2]Institut für Pharmakologie, Universitätsmedizin, Georg-August-Universität Göttingen — [3]Department of Physics, Duke University, USA

Cardiac muscle contraction involves highly coordinated dynamics, from the level of the myosin motors on the length-scale of nanometers to that of the whole organ. Many features of muscle contraction, however, emerge on the mesoscopic length scale of (half-)sarcomeres, the basic contractile unit of muscles consisting of mechanically coupled molecular motors. Basic theories of collective molecular motor dynamics predict emergent phenomena such as dynamic instabilities and spontaneous oscillatory motion due to non-monotonic force-velocity relations. On the next level of the hierarchy, when half-sarcomeres are coupled in series and in parallel, even richer emergent dynamics are expected. So far, inter-sarcomere dynamics have not been studied systematically. We have imaged sarcomere dynamics in individual stem-cell-derived cardiomyocytes with endogenous fluorescent labeling of z-bands introduced by CRISPR/Cas9, and have observed that mechanical competition leads to sarcomere de-coherence and complex dynamic heterogeneity. We have modelled the phenomena with a dynamic myofibril model of multiple heterogeneous elements with non-monotonic force-velocity relations from a complex systems / active matter perspective.

BP 6.50 Mon 17:30 Poster B2

Myosin-dependent mechanosensory adaptation in Drosophila — •Chonglin Guan[1], Kengo Nishi[1], Christian Kreis[2], Oliver Bäumchen[2], Martin Göpfert[3], and Christoph F. Schmidt[1,4] — [1]Drittes Physikalisches Institut - Biophysik, Fakultät für Physik, Georg-August-Universität Göttingen, 37077 Göttingen — [2]Max-Planck-Institut für Dynamik und Selbstorganisation, 37018 Göttingen — [3]Abteilung Zelluläre Neurobiologie, Schwann-Schleiden-Forschungszentrum, Georg-August-Universität Göttingen, 37077 Göttingen — [4]Department of Physics, Duke University, Durham, NC 27708, USA

Mechanosensory receptor cells detect and convert a diverse range of physical forces such as sound, vibration and stretch into biological (electrical) signals. The fruit fly Drosophila melanogaster possesses specialized organs, chordotonal organs (ChO), to "hear" external sound, feel airflow and keep track of body motions (propiosensing). Mechanoelectrical transduction in these organs is typically controlled by active, force-generating processes (adaptation motors). The nature of those force generators, however, is not known. We have combined electrophysiological analysis with mechanical stimulation, and have correlated mechanical properties and active manipulation with neuronal activity. We show that non-muscle myosin II activity in ChOs of Drosophila larvae is responsible for both mechanosensoy adaptation and neuronal responsiveness. Mechanical experiments suggest that elasticity and pretension in the ChO's depend on the activities of myosin motors.

BP 6.51 Mon 17:30 Poster B2

Passive and active response of bacteria under mechanical compression — •Renata Garces[1], Samantha Miller[2], and C.F. Schmidt[1,3] — [1]DPI, University of Goettingen — [2]The Institute of Medical Sciences, University of Aberdeen — [3]Department of Physics, Duke University

The ability to maintain a positive turgor pressure, by means of higher osmolarity of the cell interior than the exterior, is a requirement for proper metabolism in walled microbial cells. Turgor pressure is sensitive to changes in external osmotic conditions, and is drastically increased upon osmotic downshock, together with cell volume. Bacteria prevent lysis caused by excessive osmotic pressure through mechanosensitive (MS) channels: membrane proteins that release solutes (ions) in response to mechanical stress. The exact mechanism of channel gating in the natural setting, however, has been elusive due to the lack of experimental methods appropriate for the small dimensions of prokaryotes. We here present experimental data on the gating of MS channels of E. coli subjected to compressive force under iso-osmotic conditions. We indent living cells with micron-sized beads attached to the cantilever of an atomic force microscope (AFM) and characterize the mechanical response. We show that turgor pressure can be monitored through the measured response and quantify its value and fluctuations for individual single cells before and after MS channel gating.

BP 6.52 Mon 17:30 Poster B2

Near Real Time Analysis of Stress Fiber Formation in Stem Cells — •Lara Hauke[1], Carina Wollnik[1], Benjamin Eltzner[2], Stefan Huckemann[2], and Florian Rehfeldt[1] — [1]Third Institute of Physics, Biophysics, Georg-August-University Göttingen — [2]Institute of Mathematical Stochastic, Georg-August-University Göttingen

Human mesenchymal stem cells (hMSC) can be directed to differentiate into various lineages by different matrix elasticities. While changes in lineage specific protein expression occur over a period of days to weeks, significantly different structures of stress fibers are observable within the first 24 hours of plating [1] quantified by an order parameter S. With our massively parallel live-cell imaging set-up we record cells under physiological conditions (37 °C, 5 %CO2) over a period of 24-48 hours to obtain a statistically sufficiently large data set. We aim for a full representation of filament processes over time and space allowing for statistical analysis. This unbiased classification will be represented by persistence in space and time and potential cross-talk with other cytoskeletal components. For this we developed the FilamentSensor [2,3] a freely available tool for near real-time image analysis of stress fibers. We present experimental data where we can distinguish the development of hMSCs on 1 kPa, 10 kPa and 30 kPa elastic substrates with 99 % confidence and are working on single filament tracking and better analysis of orientation fields.

References: [1]A. Zemel, et al., Nat. Phys., 2010. [2]www.filament-sensor.de [3]B. Eltzner, et al., PLoS One, 2015.

BP 6.53 Mon 17:30 Poster B2

Recovery behavior of stretched single vimentin filaments — •Julia Kraxner, Johanna Block, and Sarah Köster — Institut für Röntgenphysik, Georg-August-Universität Göttingen

Varying mechanical properties of different cell types are determined by the cytoskeleton. The cytoskeleton consists of microtubules and microfilaments, which are conserved throughout all metazoan cell types, and different types of intermediate filaments (IFs), expressed in a cell-type specific manner. Therefore, IFs are believed to have an important impact in determining the mechanical properties of different cell types. Using optical tweezers, combined with microfluidics and fluorescence microscopy, we directly probe the stress-strain behavior of single IFs. Regarding the force-strain curves, stretching a single filament shows three regimes: the elastic stretching of α-helices, a plateau region and a stiffening at high forces. One interpretation of this behavior is that within this plateau regime the α-helices in the rod-domain of the vimentin monomers uncoil to β-sheet like structures. This process is called α-β-transition and it is suggested to be reversible even though the energy barrier between these two states is quite high. Here, we investigate the filament recovery after this α-β-transition of untreated and chemically fixed vimentin filaments.

BP 6.54 Mon 17:30 Poster B2

Influence of Ions on the Assembly of Vimentin Intermediate Filament — •Manuela Denz and Sarah Köster — Institut für Röntgenphysik, Georg-August-Universität Göttingen

Intermediate filaments (IFs) are part of the cytoskeleton, together with microfilaments (MFs), microtubules (MTs), molecular motors and cross-linkers. In contrast to MFs and MTs, IFs vary between different cell types. Despite the many different types, all IFs share the same secondary structure of a helical rod domain, and intrinsically disordered head and tail domains. The assembly of IFs follows a hierarchical pathway and as the monomers are highly charged, ions can trigger the assembly. Therefore, it is of high interest to study the influence of different ions on the assembly. In this study we focused on the IF protein vimentin. As a buffer system, MOPS (3-(N-morpholino)propanesulfonic acid) was chosen. We used two methods for our study: (i) small angle x-ray scattering (SAXS), a technique that probes primarily the lateral assembly of vimentin monomers into so-called unit-length filaments. (ii) Additionally, we employed atomic force microscopy, with which we directly imaged individual filaments. We tested the influence of several different ions with varying valence, sizes and concentrations on assembly. Our study helps to understand the molecular charge interactions between vimentin monomers or higher order assemblies. The variation in filament thickness, compactness or homogeneity that is observed in different ionic environments may eventually play a role in cells, where differently built filaments locally define different mechanical properties of the cytoskeleton.

BP 6.55 Mon 17:30 Poster B2

Ion Depending Stress-strain Behavior and Interaction of Intermediate Filaments — Anna Schepers, •Charlotta Lorenz, Johanna Block, Julia Kraxner, and Sarah Köster — Institute for X-Ray Physics, Georg-August-Universität, Göttingen, Germany

The cytoskeleton, consisting of microtubules, actin filaments and intermediate filaments (IFs), is essential for the survival of the cell. Only intermediate filaments are expressed in a cell-type specific manner. Therefore, they are ideal candidates to tune the stability and mechanics of a cell to the environment and requirements. In cells, IFs usually form networks which have been thoroughly studied in vitro by rheology. The properties of single filaments, but also the network structure itself, influence the results derived from rheology. To decouple these two effects, we measure the interaction of two single vimentin IFs with optical trapping in combination with microfluidics and fluorescence microscopy. The interactions between IFs depends on the concentration and ionic strength of surrounding ions. We study how these ions influence the interactions and the stress-strain behavior of single filaments. Thus, we also quantify the effect of ion addition to single vimentin and keratin IFs. We suggest that the cooperativity between monomers within the IF is enhanced upon ion addition, which can be modeled theoretically. Results from a Monte-Carlo simulation support our model qualitatively.

BP 6.56 Mon 17:30 Poster B2

DNA Damage and its Influence on the Mechanical Properties of the Nucleus — •Nora Olszok[1], Alia Dos Santos[2], Christopher Toseland[2], and Florian Rehfeldt[1] — [1]University of Göttingen - Third Institute of Physics - Biophysics — [2]University of Kent

In response to DNA damage actin is imported into the nucleus, nuclear actin strands are formed and the chromatin structure is remodeled [C. P. Caridi et al. *Nature* (2018); C. Andrin at al. *eLife* (2015); M. J. Kruhlak et al. *The Journal of Cell Biology* (2006)]. This change in the nuclear "cytoskeleton" might change the mechanical properties of the nucleus. We investigated such potential changes with a combined study using fluorescent microscopy and atomic force microscopy (AFM). Following systematically induced DNA damage by cisplatinum we measured the mechanical properties of isolated nuclei and nuclei in whole adhered cells. Here, we collected force maps of the nucleus and its surroundings and extracted an effective Young's modulus. Complementary we use fluorescence microscopy to assess the amount of DNA damage (by staining for phosphorylation of the histone H2A.X.) that can be quite heterogeneous within a cell population treated with cisplatinum. These measurements were complemented with similar experiments on elastic polyacrylamide (PA) gels to acoount for the diverse *in vivo* micro-environments cells encounter.

In summary, we see a clear impact of DNA damage on nuclear mechanics, that might help to elucidate further the underlying mechanisms of cellular damage remedy.

BP 6.57 Mon 17:30 Poster B2

Automated tracing algorithm for scanning electron microscopy images of the actin cortex — •Moritz Schu[1,2], Daniel Flormann[2], and Franziska Lautenschläger[2] — [1]Saarland University — [2]INM-Leibniz Institute for New Materials

The actin cortex is a thin layer of actin, myosin, and actin-binding proteins that supports the membrane of animal cells. It defines cell shape and plays a fundamental role in cell motility. Several researchers have already imaged the actin cortex using scanning electron microscopy (SEM) after removing the membrane with detergents. In their works the SEM images have been compared mostly qualitatively. Quantitative fibre image analysis tools already exist, but are not well adapted for SEM images of the actin cortex. This leaves only the possibility for manual image analysis that is prone to bias and cumbersome. Therefore, we developed an automated vectorial fibre tracing algorithm based on the Hessian of Gaussian convolution, that is applicable to SEM images and allows extraction of useful parameters such as mesh hole size and relative angle distribution. The algorithm has been tested on SEM images of the actin cortex of retinal pigmented epithelial cells (RPE-1) and is likely applicable to a wide range of image types. This method is well suited to highlight differences between cell types or conditions and is adaptable to any fibre system.

BP 6.58 Mon 17:30 Poster B2

Failure of Biological Networks with Dynamic Crosslinks — •Mareike Berger, David Brückner, and Chase Broedersz — Ludwig-Maximilians-Universität, Munich

The cytoskeleton is a complex network of crosslinked biopolymers, which is crucial for cellular rigidity and cell motility. By remodeling on different time scales, it allows the cell to both withstand stress and adapt to external forces. Rheological experiments with reconstituted crosslinked actin filament networks have revealed a complex, time-dependent stress response that depends sensitively on the properties of the crosslinks. In a simple model of a dynamically crosslinked network, we investigate the rheology and rupture behavior of such transient networks. We find that in a network with fixed crosslinks, the rupture stress is determined by a characteristic stress distribution in the network, where highly stressed crosslinks in the vicinity of defects that exceed their maximum extension threshold cause the failure of the network. In contrast, a network with dynamic crosslinks exhibits an entirely different, system-size dependent rupture mechanism. This model therefore reveals two distinct rupture mechanisms that could provide a conceptual framework for the rupture dynamics of experimental systems.

BP 6.59 Mon 17:30 Poster B2

Influence of Intermediate Filaments on Microtubule Dynamics and Organisation — •Laura Schaedel, Charlotta Lorenz, Susanne Bauch, and Sarah Köster — Institut für Röntgenphysik, Universität Göttingen

The cytoskeletal networks are involved in fundamental cellular functions such as the control of cell shape and mechanics. They are composed of different types of biopolymers that have substantially distinct mechanical, structural and biochemical properties. These con-

trasting characteristics make the study of the interactions between the cytoskeletal subsets interesting, as cells are likely to regulate and combine them in a coordinated manner in order to efficiently carry out diverse processes. Here, we study the direct interaction between two major components of the cytoskeleton - vimentin filaments, one of the most abundant members of the intermediate filament family, and microtubules - in a reconstituted in vitro setup. We build different vimentin network architectures and characterise their impact on microtubule dynamics and mechanics. With our minimalist approach, we aim at better understanding the fundamental properties of vimentin-microtubule composite network architectures and self-organisation.

BP 6.60 Mon 17:30 Poster B2

Active contraction of biopolymer networks in elastic confinement — •Johannes Flommersfeld — Center for NanoScience (CeNS), Department of Physics, Ludwig-Maximilans-Universität München, Germany

Mechanical properties of cells are largely determined by their cytoskeleton, a complex network consisting of biopolymers and molecular crosslinks. The interaction of actin filaments and the molecular motor myosin plays a central role in cell biology, since it gives rise to various forms of cell movement including muscle contractions and cell division. In vivo such actin myosin networks are usually confined by an elastic cell membrane. Recent studies of confined active fluids have revealed a strong dependence of the systems properties on the parameters of the confining walls, which is in stark contrast to passive systems. Since actin-myosin assemblies are intrinsically active, these findings raise the question if the properties of the boundaries influence the behavior of such networks. To investigate this question, we present a simple model of contractile networks, with which we can investigate how the boundaries steer the dynamics and the final state of an actively contracting network.

BP 6.61 Mon 17:30 Poster B2

Dynamic properties of actin cortex depend on the adhesion state of cells. — •Kevin Kaub[1,2], Emmanuel Terriac[1], and Franziska Lautenschläger[1,2] — [1]INM, Saarbrücken, Germany — [2]Saarland University, Saarbrücken, Germany

The actin cortex plays an important role in mechanical stability and migration. In recent years new information on the structural and the dynamical properties of the actin cortex have been obtained but their interplay and their link to mechanical properties is still poorly understood. For adhered cells it has been shown that there are two essential processes that constitute the dynamics of the cortex. These processes are linked to the polymerisation mechanisms of actin filaments: one, fast, is induced by Arp2/3, while the other, slower, is induced by formins. Furthermore it has been established that these processes contribute to the overall dynamics in different proportions. Finally, the activity of the molecular motor myosin II is another factor to take into account in order to link the structure and the mechanical properties. In the case of suspended cells, there have been conflicting reports on the role of myosin activity in regards to the stiffness.

It is our goal to understand this contradiction. To that aim, we analyzed the dynamical properties of the actin cortex by the use of FRAP (Fluorescence recovery after photobleaching). We further assessed the influence of myosin, Arp2/3 and formin inhibition in different states of adhesion. Our results shows that the dynamical properties of the actin cortex are adhesion-state specific.

BP 6.62 Mon 17:30 Poster B2

Vimentin intermediate filaments rings deform nucleus during the first steps of adhesion — •Emmanuel Terriac[1], Susanne Schütz[2], and Franziska Lautenschläger[1,2] — [1]Leibniz Institute for New Materials, Saarbrücken, Germany — [2]Faculty NT, Saarbrücken, Germany

The role of vimentin intermediate filament in different cellular processes, such as cell migration or cellular mechanics has been increasingly studied during the last decade.

Here, we show an unreported phenotype during the first hours of adhesion: filamentous vimentin is found in close vicinity of the cell nucleus and occasionaly, nuclei-deforming vimentin rings could be observed. We show that the accumulation of filamentous vimentin is decreasing over time as a function of the adhesion affinity of the cell for the substrate. Most structures are dissolved within the first 6 hours after depositing the cells over the surface which may be the reason of why these structures are not widely reported yet.

We propose that upon forced detachment of cells by conventional techniques such as trypsinization, cells are not able to control the depolymerization of vimentin while this step is controlled during mitosis. Due to the entanglement of the nucleus within the vimentin fibers the nucleus is deformed during spreading, potentially caused by the stretching of the entire vimentin network. This deformation is released once vimentin filaments get slowly dissolved and recycled during full adhesion. The implication of the strong applied forces on the nucleus via this mechanism remains to be investigated in future.

BP 6.63 Mon 17:30 Poster B2

Formation of Microtentacles — •Lucina Kainka[1,2], Emmanuel Terriac[1,2], Ludger Santen[2], and Franziska Lautenschläger[1,2] — [1]NM - Leibniz Institut for New Materials, Saarbrücken, Germany — [2]Saarland University, Saarbrücken, Germany

Microtentacles (McTNs) are tubulin based membrane protrusions appearing in circulating tumor cells and playing a significant role in tumor cells reattachment efficiency. A weakened actin cortex enables microtubule to form protrusions with a diameter of less than 1 μm and a length of tens of μm. Using cytoskeletal drugs which are targeting the actin cortex integrity and its contractility, we induce McTNs even in non-cancerous RPE1 cells. We investigate the presence of microtubules and actin as well as vimentin, which has been hypothesized to stabilize McTNs [1], under those conditions. We further establish a statistic over the number and lengths of McTNs depending on different drug concentrations applied. Experiments on the dynamics of McTNs, especially during retraction after drug wash-out, give a better insight in the role of individual cytoskeletal elements. Understanding the mechanisms of the formation of McTNs may help the development of new cancer therapies targeting CTCs in the microvasculature.

[1] R.A. Whipple, E.M. Balzer, E.H. Cho, M.A. Matrone, J.R. Yoon, S.S. Martin, Vimentin Filaments Support Extension of Tubulin-Based Microtentacles in Detached Breast Tumor

BP 6.64 Mon 17:30 Poster B2

The Influence of Force on the Self-Assembly of Myosin II Minifilaments — •Justin Grewe[1,2], Kai Weissenbruch[3], Martin Bastmeyer[3], and Ulrich S. Schwarz[1,2] — [1]BioQuant, Heidelberg, Germany — [2]Institute for Theoretical Physics, Heidelberg, Germany — [3]Karlsruhe Institute of Technology, Germany

Force generation and self-assembly are two central processes in biological systems that usually are considered in separation. However, the signals that activate non-muscle myosin II simultaneously lead to self-assembly into myosin II minifilaments as well as progression of the motor heads through the crossbridge cycle. Here we investigate theoretically the possible effects of coupling these two processes. Our assembly model, which builds upon a consensus architecture of the minifilament, predicts a critical aggregation concentration at which the assembly kinetics slows down dramatically. We validate our model by comparing fluorescence recovery after photobleaching simulated with our model against experimental results. Our model also predicts that increasing actin filament concentration and force both lead to a decrease in the critical aggregation concentration. We suggest that due to these effects, myosin II minifilaments in the cell might be in a supercritical state that can react faster to changing conditions than in solution.

BP 6.65 Mon 17:30 Poster B2

A dynamic model for the cytoskeleton of malaria-infected RBCs — •Julia Jäger[1,2], Michael Lanzer[3], and Ulrich S Schwarz[1,2] — [1]Institut für Theo- retische Physik, Universität Heidelberg — [2]Bioquant, Universität Heidelberg — [3]Parasitologie, UniversitätsKlinikum Heidelberg

Once inside the body, malaria parasites invade red blood cells (RBCs) in order to hide from the immune system and to digest hemoglobin. Over the course of 48 hours the parasite completely remodels the red blood cell, so that the cell becomes round and stiff, and eventually breaks open. The main point of attack by the malaria parasite is the spectrin-actin network underlying the membrane. It has been shown that the parasite removes some of the actin junctional points and uses this actin to build up its own filament system inside the RBC. We develop a particle-based reaction-diffusion model, which captures this remodeling process and examine possible mechanisms by which the parasite could induce the actin mining. In the long run, such a model might help to identify possible ways to interfere with the parasite lifecycle.

BP 6.66 Mon 17:30 Poster B2

Multi-scale microrheology using fluctuating semiflexible filaments as stealth probes — •Kengo Nishi[1], Fred MacKintosh[2], and Christoph Schmidt[1,3] — [1]University of Goettingen, Goettingen, Germany — [2]Rice University, Houston, USA — [3]Duke University, Durham, USA

Microrheology is commonly performed using micron-sized beads embedded in the (soft)medium to be studied. Inserting beads can be problematic in confined or hard to access places and can cause artefacts. Here, we introduce the use of single-walled carbon nanotubes (SWNTs), which are model semi-flexible polymers with non-photobleaching fluorescence, as stealth probes. We embedded SWNTs in viscoelastic media and analyzed thermally driven shape fluctuations. We show that the bending dynamics of SWNTs embedded in soft media can be used to probe the viscoelastic properties of such media at multiple scales, corresponding to the wavelengths of the modes analyzed. We found that the viscoelastic moduli of polymer solutions measured by SWNTs are in excellent agreement with those by measured by conventional micro/macrorheology, which validates the method.

BP 6.67 Mon 17:30 Poster B2

Super-resolution microscopy of the bacterial cell wall synthesis machinery — •Julian Roth and Alexander Rohrbach — Albert-Ludwigs-Universität, Freiburg, Deutschland

We constructed a total-internal-reflection fluoresecence structured illumination microscope (TIRF-SIM) with 10Hz frame rate, which enables us to gain a better view on the cell wall synthesis of the bacterium Bacillus subtilis, since it is still unclear how bacteria build, maintain and expand their cell wall. The actin-like, cytoskeletal protein MreB is an essential component of the bacterial cell-shape generation system. MreB filaments are thought to mechanically couple several synthesis motors that putatively synthesize the cell wall, whereas the filaments* traces mirror the trajectories of the motors. The cell wall synthesis machinery proteins, RodA and PbPH, are closely associated with MreB : PbPH is hypothesized to be the synthesis motor driving the MreB filaments, while there are indicators that RodA provides the motor with new cell wall material. By imaging these proteins with TIRF-SIM under different chemical and mechanical conditions, we are able to extract new information via trajectories providing propagation velocities as well as interaction processes and correlated population behavior at high resolution. This information is utilized to set-up an improved mechanistic model supported by simulations investigating the coupled work of possessive motors.

BP 6.68 Mon 17:30 Poster B2

Time series irreversibility and entropy production in biological systems — •Samuel Salinas Almaguer and Matthias Weiss — Experimental Physics I, University of Bayreuth, Germany

Quantifying whether a noisy signal, e.g. some fluorescence time series, originated from a non-equilibrium process is a big challenge. Differentiating between the forward time series and its inverse at least allows for identifying whether detailed balance is broken, i.e. if there is a preferred flux direction in phase space. Following previous reports, we have explored with numerical and experimental data to which extent an autoregressive model can detect broken detailed balance. We also used the approach to assign lower bounds to the system's entropy production via the Kullback-Leibler divergence.

BP 6.69 Mon 17:30 Poster B2

External forces on the cell membrane — •Kristian Blom and Aljaz Godec — Max-Planck-Institute for Biophysical Chemistry, Mathematical Biophysics Group, Göttingen, Germany

Cell adhesion is the process by which neighboring cells attach to each other through specialized adhesion molecules on the cell surface. The formation of receptor-ligand bond clusters between two cell surfaces is essential for cellular regulation, intercellular communication, immune response, tissue formation, and cell signaling.

While most of our current understanding about adhesion dynamics derives from the theory of non-interacting receptor-ligand bonds, recent experiments have revealed striking collective properties of adhesion clusters arising from a coupling of nearby individual adhesion bonds through deformations of the fluctuating membrane. However, how exactly this coupling affects the dynamics of cluster formation and dissolution remains an elusive problem.

In order to arrive at a deeper understanding of adhesion cluster dynamics under an external force we incorporated both the coupling of adhesion bonds due to membrane fluctuations as well as an external force into a theory of adhesion cluster stability. We obtained rigorous results for the depinning time statistics, i.e. the time to the state in which all N adhesion bonds become detached. The interplay between the pulling force and the inter-bond coupling yields non-trivial effects on the depinning time.

BP 6.70 Mon 17:30 Poster B2

Thermodynamics of Active Droplets — •Jan Kirschbaum and David Zwicker — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Biological cells need to organize their material in space and time. One organization principle is phase separation leading to membraneless compartments. Phase separation implies that large droplets grow at the expense of small ones. To counteract this instability cells can use non-equilibrium processes driven by the consumption of ATP. One example are active droplets, where the droplet material is created by driven chemical reactions.

We study active droplets by developing a thermodynamically consistent model combining phase separation with chemical reactions based on linear non-equilibrium thermodynamics. In the limiting case of first order reactions, hexagonal patterns are typical. Using a mathematical analogy with equilibrium systems with long range interactions we determine numerically how these patterns depend on the parameters of phase separation and chemical reactions. This analysis shows that the analytical predictions work better than expected. Our results show how cells can use chemical reactions to control the size of active droplets.

BP 6.71 Mon 17:30 Poster B2

Mechanisms of Permeation in Potassium Channels — •Maximilian Vossel[1,2] and Bert de Groot[2] — [1]Mathematical Biophysics Group, Max-Planck-Institute for Biophysical Chemistry (Göttingen) — [2]Computational Biomolecular Dynamics Group, Max-Planck-Institute for Biophysical Chemistry (Göttingen)

K^+ channels are proteins that facilitate the passive permeation of K^+ ions through the cell membrane. They conduct at rates close to the diffusion limit while selecting against Na^+ ions by more than a thousandfold. It has been confirmed that the channels' narrowest constriction – the selectivity filter – forces the K^+ ions to move in single file and is thereby responsible for both high current and high fidelity in rejecting Na^+.

In this work, we aim for a deeper understanding of the permeation mechanism by comparing computational models of different members of the K^+ channel family against each other. Using data from (recently published) non–equilibrium steady state molecular dynamics simulations of permeating K^+ channels we built discrete models of the permeation mechanism on a reduced phase space.

We could show that the 'direct knock-on' mechanism, where K^+ ions are in immediate adjacency to each other, is a robust process of permeation. Although exhibiting small, measurable variations, it is conserved in its main theme through all studied channels and force fields. Exploiting local detailed balance we estimated a lower bound for the voltage drop across the selectivity filter, finding values which are in very good agreement with those expected from the literature.

BP 6.72 Mon 17:30 Poster B2

Non-equilibrium dynamics of isostatic spring networks — •Benedikt Remlein, Federico Gnesotto, and Chase Broedersz — Arnold-Sommerfeld-Center for Theoretical Physics and Center for NanoScience, Ludwig-Maximilians-Universität München, D-80333 München, Germany

Mechanical systems exhibit rich critical behavior in the vicinity of the isostatic point. Inspired by living matter such as cytoskeletal networks and tissue, we here consider marginal assemblies driven out of equilibrium by internal activity. To date it remains unclear how the critical nature of such systems affects their non-equilibrium dynamics. We elucidate the role of the isostatic threshold in active diluted spring networks: heterogeneously distributed active noise sources drive the system into a non-equilibrium steady state. The non-equilibrium dynamics between pairs of network nodes are quantified by the characteristic cycling frequency ω – a measure of the circulation of the associated phase space currents. We reveal critical scaling of the cycling frequencies and intuitively understand their local behavior employing a mean-field approach. Overall, our work serves as a bridge connecting the well-established theory of mechanical stability to the novel field of non-equilibrium statistical mechanics.

BP 6.73 Mon 17:30 Poster B2

Theory for active transport by DNA-relaying — •Christian Hanauer and Chase Broedersz — Arnold Sommerfeld Center for Theoretical Physics and Center for NanoScience, Ludwig-Maximilians-Universität, D-80333 München

Robust and faithful segregation of chromosomes is essential for the replication of bacterial cells. In recent years, experiments have identified the biochemical and mechanical properties of the chromosome as key ingredients for active transport in bacterial cells. Intracellular cargoes, such as chromosomal ori, are thought to use chromosome fluctuations to transport themselves along a guiding concentration gradient of DNA-binding ATPases. However, a theory for this DNA-relaying is still lacking. To understand the DNA-relay mechanism, we develop an analytical framework that allows us to calculate the relaying force on the cargo. We test our predictions by Brownian Dynamics simulations. Our analytical model provides insight into how the system parameters determine this active transport mechanism.

BP 6.74 Mon 17:30 Poster B2

Interacting active droplets — •Ajinkya Kulkarni and David Zwicker — Max Planck Institute for Dynamics and Self-Organization, Göttingen

Liquid-liquid phase separation plays an important role in organizing material inside biological cells. Examples are membrane-less organelles, which can be described as liquid droplets. In equilibrium systems, droplets coarsen over time, so their size and count is not controlled. This instability could be counteracted by active processes inside cells. For instance, in active droplets, driven chemical reactions create diffusive fluxes, which affect the droplet dynamics. Consequently, multiple active droplets can co-exist.

We study how active droplets interact by numerically solving a modified Cahn-Hilliard equation and comparing the results with analytical predictions. We start by considering a single active droplet in an externally imposed chemical gradient. The results can be used to understand how two droplets interact. Our goal is to understand emulsions of many droplets, which will elucidate how cells could use driven chemical reactions to control droplets.

BP 6.75 Mon 17:30 Poster B2

Investigation of Spatial Dynamics of an Evolutionary Food Web Model on Random Geometric Graphs — •Johannes Reinhard, Tobias Rogge, and Barbara Drossel — TU Darmstadt, Germany

We examine an evolutionary food web model without population dynamics. Each species is characterized by a few traits based on its body mass, and the network context (predation, competition) determines species survival. We study a meta-network of patches coupled by migration on a random geometric graph (RGG). To this purpose we use an algorithm, based on the transition rates of the network, to divide the RGG into several modules allowing us to analyse the dynamics in and between modules. In addition to the investigation of species dispersal in dependence on the lifetime of the species our main focus is on the study of species area relationships (SARs, i.e., increase of species richness with increase of sampling area). There are two ways to determine the SAR: by looking at nested areas, as previously done, or by looking at nonoverlapping areas, such as the modules. This allows us to understand the results of a large-scale meta study that found a different scaling behaviour depending on which of the two methods was used.

BP 6.76 Mon 17:30 Poster B2

Artificial intelligence in biological physics. — •Norbert Sadler — Wasserburger Str. 25a ; 85540 Haar

Through the application of artificial intelligence to complex biological systems the machine learning and deep mind method can be verified in the areas of synthetic genetics and the Crispl-Cas technique.

The algorithms of artificial intelligence are based on methods of statistical physics and the basic matrix of the Exceptional E8-Group.

Informations:www.artificial-intelligence-in-science.com

BP 6.77 Mon 17:30 Poster B2

Sequence selection of oligonucleotides under a ligation chain reaction — •Patrick Kudella[1] and Dieter Braun[2] — [1]Patrick.Kudella@physik.uni-muenchen.de — [2]Dieter.Braun@lmu.de

The replication of information on RNA or DNA is central for the emergence of life (Szostak, 1990). Previously, the replication of one sequence has often been in the focus, but we think it is essential to monitor the replication and selection dynamics out of a completly random pool of sequences.

We focus on the transition from template-free polymerization to templated ligation. Once polymerization could create oligomers long enough to hybridize, we expect a nonlinear ligation dynamic to set in. We study whether sequences were selected at this onset of replication and if interesting non-linear and frequency-dependent behavior can be found (Toyabe, 2018).

We find, that for short strands, the ligation is dominated by the weak hybridization dynamics (ssDNA linked by Watson-Crick-basepairing (Crick, 1970)). By using adenine-thymine-only 12mer random sequences as starting material, the sequence space for the first ligation stage that creates 24mer can still be completely sampled. We could obtain more than 12 million individual strands using Next Generation Sequencing (NGS), showing a significant selection of sequences undergoing this elongation dynamics. We analyze the sequences with self-written LabView code and show how spiking with defined sequences changes the sequence selection dynamics of the replicated and remaining sequence pool.

BP 6.78 Mon 17:30 Poster B2

Chlorophyll f in the cyanobacterium H. Hongdechloris — •Züleyha Yenice Campbell, Franz-Josef Schmitt, and Thomas Friedrich — Technische Universität Berlin, Institut für Chemie, Fachgebiet Bioenergetik

In this work the excitation energy transfer (EET) processes in the antenna system of the phototrophic cyanobacterium Halomicronema hongdechloris that contains chlorophyll a and f in photosystem II with red light (720-730 nm) induced accumulation of Chl f was investigated by UV-Vis absorption spectroscopy, time integrated fluorescence spectroscopy and Decay associated spectra (DAS).

BP 6.79 Mon 17:30 Poster B2

Quantifying non-equilibrium nuclear shape fluctuations — •Heidi Somsel[1], Federico Gnesotto[3], Chase P. Broedersz[3], and Christoph F. Schmidt[1,2] — [1]Drittes Physikalisches Institut - Biophysik, Fakultät für Physik, Georg-August-Universität Göttingen, 37077 Göttingen — [2]Department of Physics, Duke University, Durham, NC 27708, USA — [3]rnold-Sommerfeld-Center for Theoretical Physics and Center for NanoScience, Ludwig-Maximilians-Universität, München, Germany

Cells actively generate forces that lead to rapid fluctuations, slow shape changes, locomotion, and more. The cell nucleus also shows shape changes and fluctuations. The main driver of active dynamics in cells is the cytoskeleton, via actin and myosin. We focus on the nuclear envelope to analyze nuclear non-equilibrium dynamics . We use fluorescent labeling of the nuclear lamina to visualize the fluctuations of this membrane. The fluctuations are analyzed using Broken Detailed Balance analysis (BDB), a technique to reveal and quantify non-equilibrium dynamics in steady-state systems. BDB is non-invasive, meaning that it does not require chemical or mechanical perturbations, which are difficult to perform in the cell nucleus.

BP 6.80 Mon 17:30 Poster B2

Gel formation of self-interacting DNA strands — •Giacomo Bartolucci — MPI PKS Dresden, Germany

Aqueous DNA solutions can exhibit a variety of condensed phases, depending on their nucleotide sequence and control parameters such as temperature and DNA concentration. It has been shown that DNA strands composed of self-complementary strand segments can form hydrogel phases. Inspired by these findings, we introduce a simple lattice model accounting for different configurations of DNA strands, namely single stranded DNA and a folded hairpin-like configuration. Our model is used to predict the phase diagrams of the solution as a function of temperature and total DNA concentration. We find that the region corresponding to gel formation is bounded by an upper and lower limiting temperature where gels dissolve. This behavior is due to the fact that at low temperature all DNA strands are folded in hairpins while at high temperature entropy spreads out open strands. Additionally, we discuss how this phase diagram is affected by the number of self-complementary strand segments. Our model serves as a starting point to understand the constituting principles underlying self-assembling bio materials based on DNA.

BP 6.81 Mon 17:30 Poster B2

Statistical Physics of Binary Decisions in *Physarum poly-*

cephalum — •Tanja Huxoll and Hans-Günther Döbereiner — Universität Bremen, Institut für Biophysik

Physarum polycephalum is a unicellular giant amoeba that has been proposed as a model organism for basal cognition. Previous work by others demonstrated that *Physarum* makes optimal decision in choosing the best possible food source and exhibits complex behaviour such as speed-accuracy trade-offs. Here, we explore the binary decision process in *Physarum*. We are interested in the partition of the slime mould between different environments measured by the occupation probability of either side. Our experimental set up consists of two different environments, which differ only in KCl concentrations. KCl acts as an attractor or repellent depending on its concentration. *Physarum* is placed at the centre and the foraging behaviour is observed over time. We propose a simple statistical two state model to describe the probabilities of the area occupation for each environment $P_s(c) = \frac{1}{1+\exp(kc)}$ with $k = 1/A \ \mathrm{d}A/\mathrm{d}c$ and P_s the occupation of the KCl side. We present our experimental results described by this model and we show that k is a measure of the percentage loss of the occupied KCl area with increasing repellent concentration.

BP 6.82 Mon 17:30 Poster B2

Probing mesoscopic dynamics in the developing *Drosophila* embryo using fluorescent carbon nanotubes — •Constantin Kohl[1], Zhiyi Lv[2], Jörg Grosshans[2], and Christoph F. Schmidt[1,3] — [1]Drittes Physikalisches Institut, Georg-August-Universität, 37077 Göttingen, Germany — [2]Institut für Entwicklungsbiochemie, Universitätsmedizin Göttingen, 37077 Göttingen, Germany — [3]Department of Physics, Duke University, Durham, NC 27708, USA

Semiconducting near-infrared (NIR) fluorescent carbon nanotubes (CNTs) are promising markers for *in vivo* studies. In this project, we use NIR fluorescent CNTs as markers for *in vivo* studies in *Drosophila* embryos. The photostable and intermittency-free NIR fluorescence of CNTs allows us to capture high frequency information of individual CNT trajectories in the whole developing organism over multiple cell cycles. We have built a setup, allowing for simultaneously imaging of CNT NIR fluorescence and nuclear His-GFP fluorescence. This enables us to capture intracellular dynamics on multiple time scales. We have combined the high frequency CNT NIR signals with the corresponding low frequency nuclear His-GFP signals. We have computed correlations of individual CNT trajectories in different fly types and in different cell cycle phases to characterize particular dynamics. Furthermore, we use NIR fluorescent CNTs in conjunction with particle image velocimetry (PIV) to capture the dynamics of the cytoplasmic flow in the developing *Drosophila* embryos.

BP 6.83 Mon 17:30 Poster B2

DNA Denaturation Induced by Local Salt Fluctuations in a Microfluidic Water Cycle — •Alan Ianeselli and Dieter Braun — Systems Biophysics, Ludwig Maximilian University Munich (Germany)

The evaporation of aqueous solutions can separate pure water from a salt-rich stock. Here, we used a thermal gradient to power a water cycle in a microfluidic chamber filled with water, salts and DNA, under conditions that mimic the Early Earth. The condensation of water vapor led to the formation of water droplets with a low salt content, which then precipitated and diluted the solution locally. The continuous evaporation, condensation and precipitation resulted in local dilution of solutes at the air-water interface. Since salts play a major role in the stability of nucleic acids, we found that the temporary low salt conditions lowered the melting temperature of dsDNA and slowed down the re-annealing process, leading to persistent strand separation at moderate temperatures. This can be important for many prebiotic replication reactions for RNA or DNA that do not tolerate elevated temperatures. The oscillatory dilution mechanism described here provides a route to overcome the strand separation problem and demonstrates microscale implementations of the hydrological cycle for the molecular evolution.