BP 17: Poster Session II

Active matter, bioimaging, biomaterials and biopolymers, cell mechanics, cytoskeleton, protein structure and dynamics, single-molecule biophysics, statistical physics of biological systems, tissue mechanics, nonlinear dynamics in biological systems

Time: Tuesday 18:00–20:30 Location: P4

BP 17.1 Tue 18:00 P4

Effect of cilia length on the motility of confined microbes — •Tom Sosniok, Alexandros Fragkopoulos, Rodrigo Catalan, and Oliver Bäumchen — University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany

Many microorganisms utilize their cilia or flagella to propel and navigate through their surrounding liquid environment. Often times though, the habitats of such microswimmers comprise confined spaces, and therefore, cell interactions with boundaries play an important role on their navigation. *Chlamydomonas reinhardtii*, a biciliated, green microalga that is commonly found in soil, typically swims in close proximity to curved boundaries [1]. We found that this near-wall swimming motility is controlled by gradients of wall curvature and steric interactions between the cilia and the surface [2]. Here we explore the effect of the cilia length on the motility and surface interactions of the cells using different *C. reinhardtii* mutant strains with different cilia lengths in quasi-2D circular confinement. We extract information about their motion from their mean squared displacements and visualize the wall-guided swimming via relative and radial probability densities. By comparing the results for the different strains we can directly analyse the influence of the cilia length on their swimming motility in confinement.

[1] T. Ostapenko, et al., *Phys. Rev. Lett.* **120**, 068002 (2018).
[2] J. Cammann et al., *Proc. Natl. Acad. Sci. U.S.A.* **118**, e2024752118 (2021).

BP 17.2 Tue 18:00 P4

Stochastic modeling of a two-component polymer engine — •Yasmin Abdelghaffar[1] and Marcus Jahnel[1,2] — [1]Cluster of Excellence Physics of Life, Technical University Dresden, Dresden, Germany — [2]Biotec, Technical University Dresden, Dresden, Germany

Long coiled-coil tethering proteins and small GTPases have recently been shown to form a new class of biomolecular motors driven by entropic collapse. The working principle of this motor is a cyclic flexibility transition of its filamentous tether, triggered by the GTPase unit. While a basic working model was proposed (Singh, 2023), many fundamental aspects of these two-component molecular motors remain unexplored. Here, we developed a stochastic model as an over-damped to-state semi-flexible polymer to describe the mechanochemical cycle that drives this motor. Using this model, we can predict how efficiency and power of this motor are affected by changes in model parameters such as persistence lengths. Additionally, by introducing force-dependent rates in the mechanochemical coupling of our model, we can potentially explain previous discrepancies in the measured hydrolysis rate of GTP between in bulk experiments, which occur under no force, and tweezer experiments, where the system is under tension. Our simulation study thus makes an indication on the chemical nature of the coiled-coil protein within the motor, identifying it as a potential GTPase-activating protein.

BP 17.3 Tue 18:00 P4

Modeling dynamics and density distribution of magnetotactic bacteria in traps — •Theo Richter, Sascha Lambert, and Stefan Klumpp — Institut für Dynamik komplexer Systeme, Universität Göttingen, Göttingen, Germany

Magnetotactic bacteria are microorganisms that navigate using internal magnetosomes, aligning them along magnetic fields. They represent an intriguing model system for studying active Brownian particle dynamics under an external alignment field. Previous studies have analyzed their movement through crowded channels, where the orientation along the magnetic field and their interaction with obstacles prove to be important mechanisms for navigation. In such complex environments, bacteria often find themselves trapped in corners, where the dynamics of how they escape these traps are crucial and remain mostly unexplored.

In this work, we aim to understand the density profiles, escape rate and general dynamics of single active Brownian particles under an alignment field inside trapping geometries. We investigate these quantities via simulations in varying trap geometries, with a focus on triangular traps, characterizing the effects of system parameters such as magnetic field strength and particle-wall interactions. We relate the behavior of the bacteria in these geometries to the sedimentation of active Brownian particles.

BP 17.4 Tue 18:00 P4

Light-switchable adhesion and clustering of *C. noctigama* at liquid-air interfaces — •Gustav Nolte, Alexandros Fragkopoulos, and Oliver Bäumchen — University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany

Microalgae are unicellular photoactive organisms that are ubiquitous in liquid-infused natural environments. The biciliated microalga *Chlamydomonas reinhardtii* shows light-switchable adhesion and clustering at surfaces, a process so far exclusively observed for solid-liquid interfaces [1,2,3]. Here we report on the light-switchable formation of clusters by *Chlamydomonas noctigama*, a related species with increasing relevance in the field of optogenetics, at liquid-air interfaces. The morphology and dynamics of these clusters differ significantly from the clusters formed by *C. reinhardtii*. Apart from the average cluster size and polydispersity, the growth dynamics of individual clusters are studied for a wide range of cell densities. We find a critical cell density above which the number of clusters decreases over time. For the underlying principles of cluster formation and dynamics, we address potential mechanisms like preferential attachment and Ostwald ripening. Reversible clustering may provide an advantage for *C. noctigama* by allowing the cells to accumulate in locations optimal for photosynthesis while also increasing resilience to environmental stress within the cluster.

[1] S. Till, et al., *Phy. Rev. Res.* **4**, L042046 (2022).
[2] R. E. Catalán, et al., *Soft Matter* **19**, 306 (2023).
[3] C. T. Kreis, et al., *Nat. Phys.* **14**, 45 (2018).

BP 17.5 Tue 18:00 P4

The Dynamics of Spatiotemporal Self-organization in Active Turbulence — •Henri Jörn Schmidt — Max-Planck institute for self-organisation and dynamics, Göttingen, Germany

Spontaneous pattern formation in nature has been subject to extensive research in recent decades, with more and more emphasis being put on the dynamics of their creation processes.

In this work we investigate coherent structures in fluid flows. Specifically, this work concentrates on eddy currents found in the turbulent regime of active nematics. We analyse their formation and evolution as well as how their dynamics is affected by the cross-talk between different length scales. In doing so, we introduce a new methodology to record the overlaps of eluded structures in an agent-based approach. This allows for size changes in individual structures without inflicting biases in the computed intersection ratios.

Our results seem to indicate no particular cascade of different length scales. However, we do observe an universal evolution of the eddy currents, marked by a pronounced growing and shrinking phase. Usually, these stages take place within an encapsulating parent structure. Likewise, as the eddies have attained their nominal size, they give rise to new eluded structures themselves. These dynamics seem to be independent from both, the size ratio of clusters and their elapsed life time.

BP 17.6 Tue 18:00 P4

Macroscopic transports in cellular aggregates driven by dipole forces — •Subhadip Chakraborti[1,2] and Vasily Zaburdaev[1,2] — [1]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [2]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany

The large-scale collective behavior of biological systems can be understood through macroscopic transport processes that emerge from the active interactions of individual components at the microscopic level. A striking example is the clustering and the associated transport slowdown observed in colonies of *Neisseria gonorrhoeae* bacteria, driven by active, contractile forces mediated by pili. In this study, we analytically

derive the fluctuating hydrodynamics from the microscopic dynamics of a 2D model system representing an *N. gonorrhoeae* bacterial colony. The hydrodynamic current of cells involves two macroscopic transport coefficients: bulk diffusivity and conductivity, which generally depend on cell density and other microscopic parameters. Remarkably, our simulation results strongly support the analytical predictions of transport slowdown during the colony formation process. Beyond bacterial colonies, these findings offer insights into how contractile forces influence transport in other biological systems, such as tumor spheroids and neuronal organoids, and suggest experimental approaches for studying these phenomena.

BP 17.7 Tue 18:00 P4

Dynamics, stresses and cell fate in confluent cell monolayers — •Stefano Villa[1,2], Giorgio Scita[3], Roberto Cerbino[4], and Fabio Giavazzi[2] — [1]Max Planck Institute for Dynamics and Self-Organization, 37077 Göttingen — [2]Universitá degli Studi di Milano, 20090 Segrate — [3]IFOM-FIRC Institute of Molecular Oncology, 20139 Milan — [4]University of Vienna, 1090 Vienna

Confluent cell monolayers are 2D active systems exhibiting a variety of dynamical states, ranging from solid-like jammed systems to fluid-like flocking systems. Such a rich panorama results in different mechanical stresses the single cells within the monolayer are subjected to. Due to their impressive complexity, cells do not merely react to the mechanical stresses but actively interact with the environment, e.g. adapting their mechanical properties to the stimuli. The investigation of the close interplay between dynamical state and mechanical properties of tissues is therefore of paramount interest for unraveling how cells respond to mechano-physical stimuli. We present a detailed analysis based on cell segmentation performed on time-lapse microscopy videos showing the effect of motility-induced stresses on the single cell mechanics, comparing cell models mimicking healthy tissues and tumor-like tissues. We show how the increase in dynamics leads to larger cell deformations to which the cells respond by increasing the stiffness of the nucleus. Finally, we show how mechanical stresses within the monolayer can affect tissue morphogenesis in real systems, thus highlighting once again the relevance of mechano-physical stimuli for the cell and tissue development and fate.

BP 17.8 Tue 18:00 P4

Analysis of Wall-Torques for Rod-Shaped Active Particles — •Merle Duchêne, Sascha Lambert, and Stefan Klumpp — University of Göttingen, Institute for the Dynamics of Complex Systems, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

The motility of living things and synthetic self-propelled objects is often described using Active Brownian particle models. To account for interactions with complex environments, this model can be expanded with empirical forces or torques, such as those describing their alignment with an obstacle or wall after a collision. Here, we evaluate the quality of these empirical models by comparing their output predictions with trajectories of rigid rod-shaped active particles that scatter sterically at a flat wall. Specifically, we analyze the torque reorienting the rod-shaped particle and compare it to predictions from a phenomenological model. We employ a classical least-squares method to evaluate the instantaneous torque and identify essential model parameters. In addition, a Bayesian inference procedure can be applied to construct the posterior distribution of plausible model parameters which provides a complementary perspective to the least-squares analysis.

BP 17.9 Tue 18:00 P4

Onset of bioconvection in a simple continuum model — •Marius M. Kaiser, Fabián Álvarez-Garrido, and Michael Wilczek — Universität Bayreuth

Dense suspensions of swimming micro-organisms show bioconvection, i.e.˜the emergence of self-organized flow patterns much larger than the individual swimmers, under certain conditions. Here, we analyze the onset of bioconvection in a simple continuum model. The model is derived from the Fokker-Planck equation for the swimmer concentration field and the swimmer orientation field [Pedley, J. Fluid. Mech. 647, 335 (2010)] coupled to the Navier-Stokes equation, in which we only consider buoyancy effects (no cell stresses) and approximate higher-order moments in terms of the polar order parameter. A linear stability analysis in the idealized case of a prescribed polar orientation field shows that the system exhibits a type-II instability. The results of our linear stability analysis are in agreement with direct numerical simulations of our model. Simulations of the model, now with dynamically evolving polar orientation field, suggest that the type of spatial instability remains the same, albeit with shifted critical values. Our findings shed light on the mechanism driving pattern formation in this type of suspensions.

BP 17.10 Tue 18:00 P4

DNA origami laden with bespoke magnetic nanocubes: A route to programmable torques at the nanoscale — Florian Rothfischer[1], Yihao Wang[2], Lennart Weiss[1], Christopher Pauer[3], Kevin Lang[3], Susanne Kempter[3], Rabia Amin[2], Elena Eiwanger[3], Jan Lipfert[4], Tim Liedl[3], Friedrich C Simmel[1], Joe Tavacoli[3], and •Aidin Lak[2] — [1]Physics Department E14, Technical University Munich — [2]Institute for Electrical Measurement Science and Fundamental Electrical Engineering and Laboratory for Emerging Nanometrology (LENA), TU Braunschweig — [3]Faculty of Physics and Center for NanoScience, LMU Munich — [4]Institute for Physics, Augsburg University

Magnetic-field responsive actuators offer minimally-invasive and deep-tissue perturbation of cellular processes. Despite progress, the magnetic manipulation of cells at the single receptor level is still challenging; magnetic nanoparticles (MNPs) can only exert ˜ fN forces. To achieve biologically relevant pN forces, it is necessary to assemble MNPs together in a controllable manner. This has not yet been achieved utilizing soft-synthetic templates, where control over the number, and orientation of MNPs remains a challenge. DNA origami (DNAO) can overcome this limit, specifically so for its capacity to arrange nanoparticles at high spatial resolution. Here, we demonstrate assembly of bespoke MNPs on 6 helix-bundle DNAO and show the controlled magnetic rotation of magnetic DNAOs under circulating magnetic fields of 8 mT. Our magnetic DNAOs are promising torque nanoprobes for activation of sub-cellular processes at high resolution.

BP 17.11 Tue 18:00 P4

Engineering Shear-Thinning Hydrogels: A Dynamic Scaffold for 3D Tissue Culture — •Bruno Schmelz[1], Fen Li[2], Kai Zhang[2], and Timo Betz[1] — [1]Third Institute of Physics, University of Göttingen, Germany — [2]Sustainable Materials and Chemistry, Department of Wood Technology and Wood-based Composites, University of Göttingen, Germany

Extracellular matrix (ECM) scaffolds are essential for advanced 3D cell culture systems, providing structures for cell movement as well as physical and chemical cues that promote migration, proliferation, and differentiation. Hence, the ECM is crucial for functional tissue formation. However, natural ECM materials used in vitro, such as collagen and elastin, are difficult to control regarding elastic properties, polymer mesh size, and homogeneity. Our objective is to design a dynamic hydrogel tailored to meet the specific requirements of 3D tissue culture, such as viscoelastic properties and cell-binding sites, that initially supports tissue formation but can be dissolved and replaced by cell-generated ECM. We propose a hydrogel with non-covalent cross-linking moieties that allow for reorganization by embedded cells, similar to the reorganization of collagen fibers in physiological tissues. We present the rheological properties of the hydrogels and the initial findings of cell invasion into them. When subjected to stress, the hydrogels exhibit a transition to a more liquid-like state, with the potential to solidify again upon stress relaxation. This behavior allows cells to remodel their surrounding matrix and shape their environment, as evidenced by experiments with cells cultured on the hydrogels.

BP 17.12 Tue 18:00 P4

Supramolecular ordering in lipopolymer monolayers at the air/water interface — •Issam Assi, Heiko Ahrens, and Christiane A. Helm — Institute of Physics, University of Greifswald

Lipopolymers with covalently bound poly(ethylene oxide) (EO_N) bound to the head groups have been introduced to stabilize bilayer membranes. Langmuir monolayers of the lipopolymer DSPE-EO_N at the air/water interface show in the isotherm a transition from the liquid expanded to the liquid condensed phase, which is confirmed by in-situ Grazing Incidence X-ray Diffraction (GID at DESY, Hamburg). A laterally inhomogeneous film of condensed ordered alkyl chains embedded in a matrix of solvated polymers is formed. Small Angle GID shows these lipid domains are ordered in a hexagonal lattice (repeat distance about 12 nm). The films stay homogeneous on the micrometer scale as observed with Brewster Angle Microscopy. On transferred monolayers, these supramolecular phases were observed with AFM. Fast compression of DSPE-EO_{44} monolayers is necessary to maintain the hexagonal superstructure at relatively high lateral pressures, whereas slow

compression induces a lamellar structure. Also, the superstructure of lipopolymers with shorter polymers (DSPE-EO_{11} and DSPE-EO_{22}) was explored.

BP 17.13 Tue 18:00 P4

Nanoscale drug delivery system aggregates controlably on graphite — •Henrik Siboni[1,2], Leonhard Grill[2], and Andreas Zimmer[1] — [1]Pharmaceutical Technology & Biopharmacy, University of Graz, Austria — [2]Single Molecule Chemistry, University of Graz, Austria

Nanoscale drug delivery systems are nanoparticles used to enhance the efficacy of drugs and their effectiveness depends on physical properties such as size, shape and aggregation behaviour. These parameters can be measured on a substrate with atomic force microscopy, but conserving the individual nanoparticles has proven challenging. In this study, we show that the substrate highly-oriented pyrolytic graphite allows for controllable imaging of single as well as aggregated protamine-oligonucleotide drug delivery systems. This approach can potentially be used to screen drug delivery systems and avoid unnecessary in vivo test.

BP 17.14 Tue 18:00 P4

Printed biometamaterials for mechanical regulation of cells — •Clara Schaefer[1], Alexander Berkes[2], Martin Wegener[2], Natalie Munding[1], and Motomu Tanaka[1,3] — [1]Institute of Physical Chemistry, Heidelberg University, 69120 Heidelberg, Germany — [2]Institute of Applied Physics, KIT, 76131 Karlsruhe, Gemany — [3]Kyoto University, Kyoto 606-8501, Japan

Ample evidence has shown that cells detect and respond to the mechanical properties of their microenvironment. Materials with non-conventional mechanical properties (mechanical metamaterials) have shown significant effects on human mesenchymal stem cells (Munding, et al. Adv. Funct. Mater. 2024). The key requirements are to make the unit cell size smaller than the cells and to make the materials deformable by cell traction forces. The anisotropic elastic properties lead to different responses in the traction force field that are distinct from those to bulk materials. To deal with multicellular systems and to follow cell migration, one of the challenges is to increase the lateral size to several hundreds of μm. To achieve this goal, we increased the printing speed by using a new multi-focus device in two-photon laser printing. This enables to fabricate even asymmetric metamaterial structures that can potentially be used to induce cell polarization.

BP 17.15 Tue 18:00 P4

Subcellular distribution of green-emitting carbon nanodots — •Mariell Gassen, Mine Polat, Carla Sprengel, and Thomas Heinzel — Condensed Matter Physics Laboratory, Heinrich Heine University, Düsseldorf, Germany

Carbon nanodots are promising fluorescent nanoparticles for biomedical imaging applications and drug delivery. They frequently show fluorescence in the blue range, which causes interference with the autofluorescence of the cell [1]. To circumvent this, we produced green-emitting carbon nanodots and incubated them in cells. We report tests about their subcellular distribution and studies of their suitability as carriers for active substances.

[1] S. Fasbender et al. The Low Toxicity of Graphene Quantum Dots is Reflected by Marginal Gene Expression Changes of Primary Human Hematopoietic Stem Cells. Sci Rep 9, 12028 (2019).

BP 17.16 Tue 18:00 P4

Red Blood Cells under brightfield microscopy — •Aaron Kreis, Sarah Tabea Hermes, Thomas John, and Christian Wagner — Experimental Physics, University Saarland

The observation of red blood cells under a conventional light microscope is a common practice in research and medicine. In many cases, the particular cell shape is the object of interest, see [1]. Red blood cells are composed mostly of hemoglobin, which shows its maximum absorption at $\sim$ 420 nm. Nevertheless, the cells are mostly observed under white or red light. Furthermore, the refractive index of the cytosol is greater than that of water and refraction occurs. The combination of refraction and absorption leads to very different microscopy images at different focal points. We have quantified this using calculations by ray tracing and we can explain the observed microscopy images, including the white 'halos' due to refraction at various focal positions. Diffraction isn't a major contribution in observed cell shapes. We demonstrate that the use of blue light results in a significantly better image contrast of the cell shapes without artifacts, compared to the usual observation with white light.

[1] Yoon at. al., Flickering Analysis of Erythrocyte Mechanical Properties, Biophysical Journal 97, 1606, (2009)

BP 17.17 Tue 18:00 P4

High-resolution chemical characterization of retinal pigment epithelium (RPE) using mid-infrared photo-induced force microscopy — •Maryam Ali[1,2], Robin Schneider[1], Patrick Then[1], Mohammad Soltaninezhad[1,2], Sebastian Unger[1,2], Christoph Krafft[1,2], Christine A. Curcio[3], Rainer Heintzmann[1,2], Thomas Ach[4], and Daniela Täuber[1,2] — [1]Leibniz Institute of Photonic Technology, Jena, Germany — [2]Friedrich Schiller University, Jena, Germany — [3]University of Alabama at Birmingham, United States — [4]University Hospital Bonn, Germany

Nanoscale infrared (IR) spectroscopic imaging methods fill a gap in bioimaging. Mid-IR photo-induced force microscopy (PiF-IR) combines powerful IR illumination with non-contact atomic force microscopy, resulting in high spectral and unprecedented spatial resolution ($<$ 5 nm)[1]. We applied PiF-IR to a cross-section of the retinal pigment epithelium (RPE) layer of a human donor eye. The strongly polar RPE cells play a major role in the vision cycle. Several types of autofluorescent granules in RPE cells[2] contribute to fundus autofluorescence, a clinical imaging technique used for the diagnosis of retinal diseases. In spite of their importance, the chemical composition of these organelles is not fully known. A combined chemometrics analysis of three PiF-IR hyperspectra from locations across the RPE layer reveals variations in the protein content of the surfaces of granular organelles. –[1] J. Joseph et al., Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 2024, 306, 123612. [2] K. Bermond et al., IOVS 2020, 61, 35.

BP 17.18 Tue 18:00 P4

Preparation of green fluorescent carbon nanoparticles — •Mine Polat, Carla Sprengel, and Thomas Heinzel — Condensed Matter Physics Laboratory, Heinrich Heine University, Düsseldorf, Germany

Carbon nanodots (CNDs) are promising materials for biomedical applications due to their unique fluorescent properties and biocompatible structure. However, many CNDs emit in the blue range, which is less favorable for specific applications. In this project, green-emitting CNDs were synthesized, their optical properties were analyzed, and the quantum yield was calculated. The results of absorption and emission spectra are presented.

BP 17.19 Tue 18:00 P4

Real-time monitoring of fluctuations in ATP levels and mechanobiological signatures in living cells — •Albina Nizamieva and Matthias Weiss — Experimental Physics I, University of Bayreuth, Bayreuth, Germany

Living cells are genuine non-equilibrium systems with a typical energy turnover of roughly 10^8 times thermal energy in every second. This translates to about 10^7 ATP hydrolysis events per second, with which cells may fuel, for example, signaling cascades and/or contractions of the actomyosin cytoskeleton to probe and migrate on the substrate underneath. Here we have used fluorescent reporter molecules to quantify in living cells (1) the temporally fluctuating ATP levels, and (2) fluctuations of a key mechanosensory protein that connects cellular mechanics and signaling cascades. Our data reveal marked fluctuations on the scale of minutes and beyond, whereas short-term fluctuations appear to only report on fundamental and ubiquitous physico-chemical fluctuations that are rooted, for example, in the dyes' photophysics and diffusional motion.

BP 17.20 Tue 18:00 P4

Microscopic observation of red blood cell band patterns formed by centrifugation — •Luca Hastenteufel, Thomas John, Felix Maurer, and Christian Wagner — Experimental Physics, Saarland University

Percoll is a common medium composed of coated silica particles. It is widely used as the standard medium for the density separation of cells or subcellular compounds. The centrifugation of red blood cells in Percoll exhibits a heterogeneous structure characterized by discrete bands, however the density gradient is continuous. These band patterns have primarily been analysed using macroscopic images, such as photographs. We developed a microscopic scanning setup to examine

these patterns in detail, from single cell level in μm-range up to the full pattern structure at 6 cm. This provides higher-resolution insights compared to traditional imaging methods. Additionally, high dynamic range (HDR) methods using multiple exposure levels lead to a more detailed pattern observation. Understanding these band patterns offers valuable information about red blood cell aggregation energy and the severity of related diseases.

BP 17.21 Tue 18:00 P4

Accessing local aggregation in phalloidin-stained Actin filaments using 2D Polarization Fluorescence Imaging — •Shangjun Cheng[1,2,3], Yutong Wang[1,2], Yunhao Mei[1,2], Hossein Zarei Oshtolagh[1,2], Lukas Spantzel[1,3], Patrick Then[1,4], Hans-Dieter Arndt[1], Adrian T. Press[1,3], Rainer Heintzmann[1,2], and Daniela Täuber[1,2] — [1]Friedrich Schiller University Jena — [2]Leibniz Institute of Photonic Technology, Jena — [3]Jena University Hospital — [4]Microverse Imaging Center, Jena, Germany

2-dimensional polarization-resolved fluorescence imaging (2DPOLIM) can discriminate between aggregated and non-aggregated protein forms independent of the sample's alignment by providing access to the full in-plane polarization properties of the sample. In combination with a semi-quantitative analysis of Förster Resonance Energy Transfer between similar fluorophores (homo-FRET) it can map the local aggregation in cells and tissue [1]. Actin assembly and disassembly is essential for cellular dynamics. A previous study has shown the direct link between infection and aggregation of F-Actin in hepatocytes [2]. Here, we present our speeded-up home-built 2DPOLIM setup [3] along with its calibration and image registration protocols allowing for an acquisition time in the range of a second. First results from application to the investigation of phalloidin-stained Actin filaments are presented. – [1] R. Camacho, et al., Advanced Materials, 31, 1805671, 2019. [2] P. Martinac, et al., Infection, 47, S6-S7, 2019. [3] Y. Wang, et al., Klosters, Switzerland, January 2023. doi:10.13140/RG.2.2.35169.79204

BP 17.22 Tue 18:00 P4

Liquid-cell Scanning Transmission Electron Microscopy (STEM) of isolated mitochondria and respective Au labels — •Eric Lieberwirth[1], Kevin Oldenburg[2], Anja Schaeper[3], Marcus Frank[4], Ingo Barke[1], Simone Baltrusch[3], and Sylvia Speller[1] — [1]Institute of Physics & LLM, University of Rostock — [2]ELMI-MV, University of Rostock — [3]Institute of Medical Biochemistry and Molecular Biology, Rostock University Medical Center — [4]Electron Microscopy Center, Rostock University Medical Center

In situ liquid-cell Scanning Transmission Electron Microscopy (STEM) holds the promise to observe biological organisms in a native state such as organelles, bacteria and eukaryotic cells [1,2]. In addition to acquisition of individual images, movies can be recorded during manipulation of tissue [3]. The potential radiation damage due to the transit of the electron beam through the sample is still under debate [4]. We imaged isolated mitochondria in Krebs-Ringer medium, and extracted imaging performance, and external features of radiation damage. We also study Au labels in the physiologic medium and show that atomic resolution of the nanoparticles is attainable. Such labelling is expected to increase resolution [1] and validate the presence of mitochondria in the STEM. One of the next challenges is validating the metabolic activity of the mitochondria during or upon the (S)TEM measurement.

[1] Kun He et al. (2019) J. Phys.: Condens. Matter 31 103001
[2] Frances M. Ross (2024) Micro. Tod. 32 17-22
[3] Elliot S. Pohlmann et al. (2015) Nano Lett. 15 2329-2335
[4] Yulian Wu et al. (2019) New J. Chem. 43 12548

BP 17.23 Tue 18:00 P4

Three-Axis Structured Illumination Lightsheet Microscopy — •Meelad Lalenejad and Alexander Rohrbach — University of Freiburg, Freiburg, Germany

Light-sheet microscopy (LSM) is known for increased image contrast and reduced photo-bleaching and toxicity since only those parts of the object are illuminated from the side that is in the focus of the objective lens. In addition, larger volumes are scanned plane-wise or line-wise by optimized laser beams, so LSM is significantly faster than point-wise scanning methods. However, for imaging a small number of cells, the spatial resolution is limited by the numerical aperture of the objective lens. We tackle the problem of limited resolution by combining holographically shaped illumination beams with three-axis interferometric arrangements. We use structured illumination microscopy (SIM) to obtain 3D super-resolved images in scattering media by generating interference fringes between every two beams from different illumination objective lenses.

BP 17.24 Tue 18:00 P4

Investigating Neutrophil dynamics using 200 Hz Rotating Coherent Scattering Microscopy — •Vera Obloh and Alexander Rohrbach — Lab for Bio- and Nano-Photonics, Department of Microsystems Engineering (IMTEK), University of Freiburg, Georges-Koehler-Allee 102, 79110 Freiburg, Germany

Neutrophils, the largest population of leukocytes in the human bloodstream, are initial responders in the rapid innate immune defense against most bacterial and fungal pathogens. They are activated before the complex humoral and lymphocyte-mediated processes of acquired immunity can effectively respond to an infection. To ensure effective defense, Neutrophils rapidly and efficiently move to areas of infection, based on highly dynamic processes of cytoskeleton reorganisation. Due to their ability to migrate rapidly and their availability and ease of cultivation, HL-60 Neutrophils are well suited for observations with Rotating Coherent Scattering (ROCS) microscopy, a novel 200 Hz label-free imaging technique with resolutions well below 200 nm. ROCS represents a powerful, high-speed alternative to fluorescence microscopy, especially for observations over thousands of frames. We represent first images and analyses of so far unseen details and dynamics of Neutrophil migration.

BP 17.25 Tue 18:00 P4

Characterisation of fluorescent dyes and their uptake by M2 cells using FLIM — •Jana Sütterlin[1], Francisco Páez-Larios[1,2], Lukas Harder[1], Lea Klepsch[3,4], Vivien Bachmann[5], Antje Vollrath[3,4], Paul Jordan[5], Ulrich Schubert[3,4], Oliver Werz[5], Christian Franke[1], and Christian Eggeling[1,2] — [1]Institute for Applied Optics and Biophoysics, Friedrich-Schiller-Universität Jena, Jena, Deutschland — [2]Department of Biophysical Imaging, Leibniz-Institut für photonische Technologien e.V., Jena, Deutschland — [3]Jena Center for Soft Matter, Friedrich-Schiller-Universität Jena, Jena, Deutschland — [4]Institute for Organic and Macromolecular Chemistry, Friedrich-Schiller-Universität Jena, Jena, Deutschland — [5]Department of Pharmaceutical and Medical Chemistry, Friedrich-Schiller-Universität Jena, Jena, Deutschland

Polymeric nanocarriers are used to incorporate active substances into cells, that otherwise would have limited bioavailability. To study the particle-cell-interaction, the nano-particles contain a fluorescent dye, which allows monitoring by fluorescence microscopy. Since a dye's fluorescence lifetime depends on its environment, the dye's release from the nanoparticle into the cellular cytosol can be evaluated temporally and spatially by fluorescence-lifetime-imaging (FLIM). To that end, lifetime behaviour of Nile Red, ATTO 665 and ATTO Rhodamine 3B is characterised under different solvent conditions mimicking different cellular compartments. By this, a comparison with FLIM data of live cell uptakes is possible, which can yield insights into the dynamic interaction of drug-loaded nanoparticles and their target cell.

BP 17.26 Tue 18:00 P4

MINFLUX-derived particle traces reveal Mean Back Relaxation to study active systems — •Deisel Tobias, Muenker Till, Vos Bart, and Betz Timo — Third Institute of Physics, Georg-August Universität Göttingen, Göttingen, Germany

Living systems like cells exhibit dynamics far from thermodynamic equilibrium. In order to study such non-equilibrium systems, we need to use analytical methods beyond the classical methods developed in statistical physics. In order to quantify the activity in a living, we have recently introduced the Mean Back Relaxation (MBR), which exploits a three-point probability function and is solely derived from passive measurements. A main hurdle in using the MBR in the requirement of particle trajectories with high temporal and spatial precision, that are sufficiently long to detect activity. In normal flourescence microscopy this is not possible to achieve because of probe bleaching. To overcome this, we measure the MBR using MINFLUX nanoscopy, which is able to track fluorescent particles at a spatio-temporal resolution in the order of nanometers at a frequency in the order of a few kHz. We explore the MBR of fluorescent particles in living cells and study its change under the influence of cytoskeletal inhibition.

BP 17.27 Tue 18:00 P4

Thermal and directional motion of trapped particles in periodic potentials — •Ellen Hermle and Alexander Rohrbach — Lab for Bio- and Nano-Photonics, Department of Microsystems Engi-

neering (IMTEK), University of Freiburg, Georges-Koehler-Allee 102, 79110 Freiburg, Germany

Molecular fiction can be considered as continuous on-binding and off-binding of molecules between two sliding surfaces. This complex process of energy dissipation to the environment, is important on most length scales, time scales and across disciplines. Usually, the relation between dynamic friction and velocity is quantified by a coefficient, which depends on various on- and off-binding parameters. Here, optical tweezers based Photonic Force Microscopy (PFM) has proven to be a suitable technique is used to analyse friction processes on mesoscopic length scales, specially at soft (-bio) interfaces. By 3D interferometric position tracking at 1 MHz we determine mean particle displacements and forces, as well as fluctuations of displacements and forces. Besides Brownian dynamic simulations, we present first experimental results of fluctuating particles dragged through a periodic potential, which can be generated by an optical potential from two interfering beams or by a specifically coated glass surface.

BP 17.28 Tue 18:00 P4

Investigating Ultrasonic Effects on Oral Cancer Cells Using Fluorescence Microscopy — •Wafa Tounsi, Amar Avdakovic, Vivian Maria Gulczynski, and Mathias Getzlaff — Institute of Applied Physics, University of Duesseldorf

Head and neck squamous cell carcinoma (HNSCC) is a challenging and often resilient cancer that affects many people globally. As conventional treatments sometimes fall short of effectively targeting these cancer cells without causing damage to surrounding healthy tissue, our research focuses on finding innovative alternatives. Our contribution explores the potential of using ultrasonic frequencies to selectively affect cancer cells while sparing healthy ones, offering a possible new avenue for treatment. In this study, we investigate how HNSCC cells respond to ultrasonic waves at frequencies between 20 and 250 kHz. We compare their reactions to benign oral keratinocytes, aiming to pinpoint acoustic conditions that might selectively disrupt cancer cells. In combination with Fluorescence Microscopy, we track various cellular responses, including changes in cell shape, membrane stability, and mitochondrial activity, using specific fluorochromes such as CellMask Green for plasma membranes, Hoechst for nuclear staining, and MitoTracker for mitochondria. By observing these differences, especially in the cytoskeleton, we gain valuable insights into the unique vulnerabilities of HNSCC cells, potentially paving the way for ultrasound-based, non-invasive treatments. Exploiting the distinct mechanical properties of cancer cells could enhance patient outcomes by enabling safer, more targeted treatments.

BP 17.29 Tue 18:00 P4

A flavin-based photoreceptor controls the photoactivation of ciliary adhesion in *Chlamydomonas*. — •Rodrigo E. Catalan[1,2], Antoine Girot[1,2], Alexandros Fragkopoulos[1,2], Olga Baidukova[3], Peter Hegemann[3], and Oliver Bäumchen[1,2] — [1]University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany — [2]Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [3]Humboldt University of Berlin, Institute of Biology, 10115 Berlin, Germany.

Light-activated proteins or photoreceptors play a crucial role on the behavior and, ultimately, the survival of photoactive microorganisms. The unicellular biciliated microalga *Chlamydomonas reinhardtii* has become a model organism to study light-mediated phenotypes, such as photosynthesis and phototaxis, among many others. Recently, we discovered that *C. reinhardtii* can reversibly switch on and off the adhesiveness of their cilia in blue and red light, respectively [1,2]. We characterized the action spectrum of this phenotype in wild-type (WT) *C. reinhardtii* cells via single-cell micropipette force measurements, and showed that it resembles the spectral sensitivity of a flavin-based photoreceptor. Further comparison of the ciliary adhesion forces between WT and photoreceptor-targeted mutants reveals that the deletion of two flavin-containing photoreceptors, namely animal- and plant cryptochromes, completely disrupts light-switchable adhesion.

[1] C. T. Kreis *et al.*, *Nat. Phys.* **14**, 45-49 (2018).
[2] R. E. Catalan *et al.*, *Soft Matter* **19**, 306-314 (2023).

BP 17.30 Tue 18:00 P4

Ciliary Adhesion of *Chlamydomonas reinhardtii* on Charge-Functionalized Surfaces — •Lea Rupprecht[1], Rodrigo Catalan[1], Christina Heinritz[2], Thomas Scheibel[2], and Oliver Bäumchen[1] — [1]University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany — [2]University of Bayreuth, Biomaterials, 95447 Bayreuth, Germany

Elucidating the physical phenomena underlying the interactions between microorganisms and surfaces is crucial for developing technologies to control the formation of microbial biofilms. While most studies use bacteria as model organisms, the principles of microbial adhesion remain rather elusive for eukaryotic photosynthetic microorganisms. Recently it was discovered that the model unicellular microalga *Chlamydomonas reinhardtii* adheres to surfaces by means of its two cilia under blue light [Kreis *et al.*, Nature Physics, 2018]. With *in vivo* single-cell micropipette force spectroscopy, the ciliary adhesion forces of *C. reinhardtii* on functionalized substrates were characterized to dissect the influence of surface energy, van der Waals and electrostatic interactions [Kreis *et al.*, Soft Matter, 2019]. The results suggest that the predominant nature of the protein-mediated cilia-substrate adhesion of *C. reinhardtii* is due to electrostatic interactions. Here we present adhesion force measurements of *C. reinhardtii* on poly-L-lysine- and recombinant spider silk-coated silicon, revealing no charge preference for ciliary adhesion. In contrast to prokaryotic microorganisms, our results show *C. reinhardtii* uses highly versatile cilia to achieve microbial adhesion to surfaces of a broad range of physicochemical properties.

BP 17.31 Tue 18:00 P4

Intracellular mechanics in migrating cells — •Jannis Fischer, Mohammad Amin Eskandari, and Timo Betz — Third Institute of Physics, Göttingen, Germany

To fulfill their incredibly large number of different tasks, biological cells have developed mechanisms to adapt their physical properties and appearance. The proper control of these changes is crucial, as they are not only essential for healthy cells, but can also distinguish healthy from diseased cells. Important examples related to such changes in mechanical properties are cell shape variation or cell migration. It is still not clear whether the changes in these mechanical properties are due to passive or active processes. Investigating and understanding these processes is the core of this work. For this, I will analyze the behavior of migrating cells, which are induced to move alternately on patterns and within channels. To connect the observed dynamics with the underlying mechanical properties and activities I will use the new quantity of mean back relaxation (MBR). Findings in this area could provide information for the big question of whether the mechanical properties of cells can be predicted by their activity.

BP 17.32 Tue 18:00 P4

Same, but different: Shared viscoelastic signature in hydrogels and cells — •Dorian Marx, Till M. Münker, Bart E. Vos, and Timo Betz — Third Institute of Physics - Biophysics, Georg-August-Universität Göttingen, Germany

We report the discovery of a striking "mechanical fixed point" in the response of polyacrylamide-based hydrogels to shear strain. Characterized by a pronounced and invariant relationship of parameters of the mechanical model, this leads to a convergence of the complex shear moduli of all measurements at a frequency of approximately 5 kHz. Intriguingly, reviewing existing literature reveals that this phenomenon is not unique to our simple hydrogel. Rather, there are many qualitatively similar observations in the distinct realm of (intra-)cellular mechanics, as probed by diverse techniques including optical tweezers and atomic force microscopy using many different cell types. Despite the fundamentally different natures of these systems - one being passive and at equilibrium (hydrogel), the other active and out-of-equilibrium (cell) - they show this peculiar viscoelastic signature. The existence of the mechanical fixed point hints at an unresolved constraint governing the mechanics across vastly different biological and synthetic systems.

BP 17.33 Tue 18:00 P4

: Identifying the proteins controlling the intracellular active mechanics — •Noémie Veyret, Till Münker, and Timo Betz — Third institute of Physics, University of Göttingen, Germany

Over the past few years, the study of cell mechanical properties has allowed new insights on the understanding of biological processes and life complexity. According to previous work, intracellular mechanical properties can be narrowed down to a fingerprinting of only 6 parameters. Through the use of active and passive microrheology measurements via optical tweezers, frequency dependent viscoelastic properties and intracellular activity were found to vary for different cell types. The aim of this project is to find a correlation between changes in protein expressions and mechanical fingerprint of cells. To do so optical tweezers measurements will be performed during the differentiation process

of induced Pluripotent Stem Cells (iPSCs) into cell types derived from the three germ layers, namely neurons (ectoderm), skeletal muscles (mesoderm) and hepatocytes (endoderm). This measurement allows the characterization of the mechanics during the iPSC differentiation process. In parallel, the cell proteome will be studied using mass spectroscopy. Combining both, we hope to find the connection between proteins and their mechanical role, the intracellular "mechanome".

BP 17.34 Tue 18:00 P4

Investigating the rheology of intracellular transport by magnetic tweezers — •Katharina Beitzinger, Simon Wieland, and Holger Kress — Biological Physics, University of Bayreuth, Germany

Intracellular transport is an important part of phagocytosis, the cellular internalization of extracellular objects such as bacteria or microplastic particles. After uptake, the phagosome is transported mainly by dyneins along microtubules to the perinuclear region as part of the phagosomal maturation process. However, the kinetics of the recruitment of the motors to the phagosome is largely unknown. In order to investigate the mechanics of the transport, we use magnetic tweezers in combination with paramagnetic particles, internalized by mouse macrophages. By switching the tweezers on and off periodically, we exert alternating forces on the particle during the transport. The changes in the local viscoelastic cell properties are determined by modeling the creep compliance with a power law. First experiments show that the viscosity of the cells around the phagosomes remains almost constant, while the stiffness increases over time. The change in stiffness can be an indicator for a progressive adaption of the cell towards external stress by a recruitment of molecular motors to the phagosome. We expect that a quantification of the local viscoelastic cell properties during phagosomal transport can lead to a better understanding of this fundamental cellular process.

BP 17.35 Tue 18:00 P4

Optimizing Microfluidic Synthesis of Polymer Beads for In-Vivo Force Cell Sensing — •Jordan Dieter Groh, Alejandro Jurado Jiménez, and Timo Betz — Drittes Physikalisches Institut, Göttingen, Deutschland

Since the first use of deformable beads inside living tissue as force sensors about ten years ago, the technique has been refined with the introduction of new materials and methods to measure deformation. In many experiments, polyacrylamide beads have been used to assess forces in all kinds of in-vivo and in-vitro systems such as developing embryos, cancer spheroids, or reconstituted muscle tissue. However, using shear-induced emulsions as a fabrication method still shows two main limitations: a broad size distribution and small variations in polymer stiffness. We were able to optimize the production of polyacrylamide beads in two ways. First, by adoption of flow-focusing in a microfluidic setup. This technique is commonly employed in diverse fields, including drug delivery and food industry, for creating emulsions with precise control over droplet sizes. Second, by the use of a UV light-sensitive polymerization initiator that was triggered after the emulsion was created. The UV initiation of polymerization is instrumental in avoiding clogging of the microfluidic chips as polymerization happens only after emulsification. These improvements resulted in large beads with diameters of 93 um, which are still too large for many applications. Current approaches aim to reduce the bead size to around 5 um or even below.

BP 17.36 Tue 18:00 P4

Characterizing diffusion properties at liquid-liquid interfaces in microfluidic channels — •Eric Schneider, Eric Sündermann, Bob Fregin, and Oliver Otto — Institute of Physics, University of Greifswald, Greifswald, Germany

Real-time deformability cytometry is a powerful and widely used method for investigating the mechanical properties of cells in suspension. Here, cells are deformed by hydrodynamic stress in a microfluidic system, that is comparable in size to the cells. Consequently, the range of cell sizes has to match the physical channel dimensions to ensure proper cell deformation. Virtual fluidic channels (VFCs) address this limitation, by allowing for the channel width to be adjusted within seconds. VFCs are formed by the liquid-liquid interface between two co-moving aqueous polymer solutions. The introduction of these two different polymer solutions generates a density gradient within the microfluidic channel, which can give rise to diffusive processes. We investigated the diffusive properties within VFCs and the influence of the liquid-liquid interface. For this, we examined the temporal behavior of a fluorescent dye distribution within the microfluidic chip. We modelled the diffusive behavior self-consistently by solving the kinetic diffusion equation, which accounts for the differential flow velocities within the microfluidic channel. Finally, by combining theoretical and experimental results, we determine the characteristic diffusion timescales in the VFC and across the liquid-liquid interface. With this we provide a general framework to investigate the diffusive properties along laminar flow boundaries.

BP 17.37 Tue 18:00 P4

A fast and quantitative method to study the membrane tension of suspended cells — •Eric Sündermann, Bob Fregin, Doreen Biedenweg, and Oliver Otto — Institute of Physics, University of Greifswald, Greifswald, Germany

The development of high-throughput methods for cell mechanical research is becoming increasingly important as the analysis of large samples improves the statistical robustness to identify rare cell populations and transfer results from basic science into clinical applications. Various techniques are available for bulk mechanics, but none can analyse membrane tension with the throughput of a flow cytometer.
Here, we present membrane tension cytometry (MTC), that uses Flipper-TR, a fluorescent dye with a fluorescence lifetime being proportional to the tension inside a lipid bilayer. First, we established a calibration procedure using osmotically-stressed red blood cells. Next, we move to HL60 cells, a myeloid precursor cell line, which we exposed to various chemical and mechanical stresses. We find an increased fluorescence lifetime for increasing hydrodynamic stresses, as expected. Finally, we used methyl-β-cyclodextrin and Cytochalasin D to disturb cholesterol and filamentous actin levels, respectively. Our results show, that MTC is sensitive to membrane changes while being insensitive to cytoskeletal alterations.

BP 17.38 Tue 18:00 P4

Thermomechanical properties of bat erythrocytes as a blueprint for human hibernation — •Bob Fregin[1,2], Doreen Biedenweg[1], Oliver Otto[1,2], and Gerald Kerth[3] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]German Center for Cardiovascular Research, Partner Site Greifswald, Greifswald, Germany — [3]Applied Zoology and Nature Conservation, Zoological Institute and Museum, University of Greifswald, Greifswald, Germany

The ability to sustain efficient blood circulation at low body temperatures is a critical adaptation in hibernating mammals. Here, the mechanical properties of red blood cells (RBCs) could play a crucial role, which we studied for the hibernating common noctule bat, the non-hibernating Egyptian fruit bat, and humans. Using dynamic real-time deformability cytometry RBC elasticity and viscosity were measured at physiologically-relevant time scales (Milliseconds) and temperatures (37°C, 23°C, and 10°C).

Our findings reveal a temperature-driven increase in elasticity and viscosity, which is mainly influenced by membrane properties and not the cytosol. This effect is significantly enhanced in bats. Finally, our data demonstrate that RBC membranes of both bat species display a transition to a viscous-like state at lower temperatures, which is not explained by seasonal variations of environmental factors but seems to originate from physical properties of the cell membrane. Our results suggest RBC thermomechanical properties as a target for future research on human hibernation.

BP 17.39 Tue 18:00 P4

Passively Measuring Cell Activity via Mean Back Relaxation — •Sarah Louisa Lädke[1], Till Moritz Münker[1], Julian Schulz[1], Gabriel Knotz[2], Matthias Krüger[2], and Timo Betz[1] — [1]Third Institute of Physics, Georg-August-Universität Göttingen — [2]Institute of Theoretical Physics, Georg-August-Universität Göttingen

While many statistical methods are available for the characterization of passive motion in thermodynamic equilibrium, the investigation of active motion in living systems remains a significant challenge. In particular, the study of intracellular mechanical properties requires techniques such as active microrheology to quantify the response of tracer particles to forces exerted via optical or magnetic tweezers. However, these methods often involve expensive and complex equipment, and their invasive nature can alter cellular behavior.

To address these limitations, we present an alternative approach to study intracellular mechanical properties and activity that relies only on passive measurements. To this end, we combine darkfield microscopy, highspeed imaging and image post-processing techniques to

obtain trajectories of microparticles in Hela cells with nanometer and 300 microseconds spatial and temporal resolution. To filter noise that occurs in our particle tracking, we developed a new, Bayesian approach that can reliably differentiate between noise peaks and intrinsic fluctuations found in the frequency spectrum. Using the novel observable Mean Back Relaxation (MBR), we can link the particle tracks to intracellular activity and their mechanical properties.

BP 17.40 Tue 18:00 P4

Competition between deformation and free volume quantified by 3D image analysis of red blood cell — •Pavlik Lettinga[1,2], Mehrnaz Babaki[1,2], Dmitry Fedosov[1], Amirezza Gholivand[1], Remco Tuinier[3], and Joeri Opdam[3] — [1]Forschungszentrum Jülich — [2]KU Leuven — [3]TU Eindhoven

Cells in living organisms are subjected to mechanical strains caused by external forces like overcrowding, resulting in strong deformations that affect cell function. We study the interplay between deformation and crowding of red blood cells (RBCs) in dispersions of nonabsorbing rod-like viruses. We identify a sequence of configurational transitions of RBC doublets, including configurations that can only be induced by long-ranged attraction: highly fluctuating T-shaped and face-to-face configurations at low, and doublets approaching a complete spherical configuration at high, rod concentrations. Complementary simulations are used to explore different energy contributions to deformation as well as the stability of RBC doublet configurations. Our advanced analysis of 3D reconstructed confocal images of RBC doublets quantifies the depletion interaction and the resulting deformation energy. Thus, we introduce a noninvasive, high-throughput platform that is generally applicable to investigate the mechanical response of biological cells to external forces and characterize their mechanical properties.

BP 17.41 Tue 18:00 P4

Red blood cell membrane tension modulation by photo switchable molecules — •Tim Kutz[1], Bart Vos[1], Jan Bart Ravoo[3], Andreas Janshoff[2], and Timo Betz[1] — [1]Third Institute of Physics, Georg August Universität Göttingen, Göttingen, Germany — [2]Institute of Physical Chemistry, Georg August Universität Göttingen, Göttingen, Germany — [3]Organic Chemistry Institute and Center for Soft Nanoscience, University of Münster

Cellular stiffness and surface tension are fundamental determinants of cell behavior and function. However, the precise contributions of membrane and cortical components to overall cell mechanics remain unclear. Building upon our recently developed multi-modal approach, which combines atomic force microscopy, confocal spinning disk fluorescence microscopy, and micropipette aspiration, we investigated the mechanical properties of human red blood cells (hRBC) as a model system, with a focus on membrane manipulation. By incorporating photo switchable azobenzenes into the hRBC membrane, we created a dynamic system to modulate membrane properties through light-induced conformational changes.Comparisons were made between wild-type hRBCs and those containing azobenzenes in both the cis and trans states. This approach enabled us to directly correlate changes in membrane conformation with alterations in mechanical properties. Our results demonstrate the feasibility of using photo switchable molecules to modulate cellular mechanics in a controlled and reversible manner. This approach and novel platform advances our understanding of the contribution of the membrane to cellular tension.

BP 17.42 Tue 18:00 P4

Theoretical perspectives on controlling cells by ultrasound — •Niels Gieseler[1,2,3], Falko Ziebert[1,2], and Ulrich S. Schwarz[1,2] — [1]Institute for Theoretical Physics, Heidelberg University, Philosophenweg 19, Heidelberg 69120 Germany. — [2]BioQuant, Heidelberg University, im Neuenheimer Feld 267, Heidelberg 69120 Germany — [3]Max Planck Institute for Medical Research, Jahnstrasse 29, 69120 Heidelberg, Germany

Aside from the well-known use of ultrasound in medical imaging, there are many other biomedical applications of ultrasound, including enhanced bone healing, neurostimulation and sonogenetics. Different mechanisms have been implicated for these processes, including temperature changes, cavitation, radiation forces and acoustical streaming. In this work, we are interested in the interaction between ultrasound and tissue (including organoids) at the single-cell level. Combining concepts from hydrodynamics, elasticity theory and soft matter, we aim at theoretical predictions of the relative relevance of these different effects. In particular, we use the theory of viscoelasticity to predict whether intracellular streaming and organelle movement can be controlled by ultrasound.

BP 17.43 Tue 18:00 P4

Predicting mass density of eukaryotic nuclei and cells — •Omar Muñoz[1,2,3], Abin Biswas[1,3,4], Kyoohyun Kim[1,3], Jochen Guck[1,3], Vasily Zaburdaev[1,2], and Simone Reber[4,5] — [1]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany. — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [3]Max Planck Institute for the Science of Light, Erlangen, Germany — [4]Max Planck Institute for Infection Biology, Berlin, Germany — [5]University of Applied Sciences Berlin, Berlin, Germany

Biophysical properties of the cell nucleus are important for various cellular processes from transcription to migration, but largely are still not well understood. The mass density is one such example, since we observed for a wide range of species that the cells maintain a certain nuclear to cytoplasmic mass density ratio with nuclear mass density being lower than its cytoplasmic counterpart. Moreover, in diseased states such as senescence we observed a breakdown of this density ratio where dilution of the cytoplasm made nuclei appear more dense, which suggests that the density ratio is a potential marker of proper cell functionality. Theoretical modeling can contribute to a better understanding of how this density ratio is established. There are two essential model components: a pump leak model to predict compartment volume and a model to determine the dry mass in the system, which is usually an active, dynamic process. Here we present the models for different systems such as human cells, nuclei in Xenopus egg extract and discuss their differences.

BP 17.44 Tue 18:00 P4

Modeling the endothelial cytoskeleton response to blood flow — •Berin Becic and Stephan Gekle — Biofluid Simulation and Modeling, University Bayreuth, Germany

As present in blood flow, it was observed that a shear flow leads to an alignment of endoethelial cells, which is connected to an alignment of its cytoskeleton. Understanding this behavior is important as its failure can lead to chronic inflammation which is one cause for the formation of artherosclerosis and other cardiovascular diseases. In order to do this we develop a three-dimensional model for the formation of the cytoskeleton based on the stress- and strain-dependency of the stress-fiber association and dissociation dynamics, as proposed by Deshpande et al (A bio-chemo-mechanical model for cell contractility , PNAS 2006). This model also offers the opportunity to study the spatially resolved formation of the cytoskeleton as observed in cells adhering to a substrate or the mechanic interactions between the cell and its nucleus.

BP 17.45 Tue 18:00 P4

Combining computational and experimental advances in microparticle traction force microscopy — •Bastian Kraus[1], Simon Brauburger[1], Tobias Walther[2], Kerstin Göpfrich[2], and Ulrich S. Schwarz[1] — [1]Institute for Theoretical Physics, Heidelberg University, 69120 Heidelberg, Germany — [2]Center for Molecular Biology of Heidelberg University (ZMBH), Heidelberg University, 69120 Heidelberg, Germany

Traction force microscopy (TFM) infers cellular forces from the motion of fiducial markers embedded in soft elastic substrates. Over the last years, this approach has been extended to elastic microparticles, typically made from polyacrylamide. In contrast to flat substrates, this approach allows to infer forces either from the motion of embedded fiducial markers or from the deformation of the surface. Here, we compare these two different approaches from the viewpoint of elasticity theory and with computer simulations that include the image processing steps. We then apply the method to experimental data from DNA microbeads, for which one can implement markers for both bulk and surface deformations.

BP 17.46 Tue 18:00 P4

An FEM based framework to reconstruct cellular traction forces in arbitrary geometries — •Cornelis Mense and Ulrich Schwarz — Heidelberg University

In the last two decades, the reconstruction of cellular traction forces has been a valuable tool in mechanobiology and biomedical experiments. Traction forces are traditionally computed for displacements of soft elastic substrates, imaged using fluorescent micro-beads. These substrates have largely been planar surfaces, owing to the availability of methods by which to analyse such experimental data. But, as of late,

a curiosity and drive has arisen to extend these experiments to arbitrary three-dimensional geometries. Here, a framework is proposed to inversely reconstruct tractions using the Finite Element Method. This method attempts to reduce noise and non-physical tractions by iteratively projecting experimental displacement fields onto force-balanced configurations using the principle of virtual work. The efficacy of the method is demonstrated through toy problems, wherein tractions are first prescribed onto a geometry to generate mock data sets of displacement fields. These fields are then artificially made noisy, after which the FEM software is tasked with retrieving the initially prescribed tractions. The experimental design space, that would be opened up by this framework, could prove a valuable tool in further understanding cell motility.

BP 17.47 Tue 18:00 P4

Investigating Particle Binding above Epithelial Cells with Photonic Force Microscopy — Nils le Coutre and •Alexander Rohrbach — IMTEK, Department for Microsystems Engineering, Freiburg, Germany

A significant portion of today's airborne particulates originates from human activities such as industrial processes and the combustion of crude oil-based fuels. This has been linked to an increased risk of diseases including asthma, lung cancer, and cardiovascular pathologies, correlating significantly with the inhalation of particulate matter. Here, we investigate the fluctuation-based interaction of single optically trapped particles with epithelial cells. Using photonic force microscopy, we trap the particles through a layer of epithelial cells and interferometrically track the thermal motions of the particle with the goal to recover binding and friction parameters in contact with the cell surface. This approach is challenging since the cell perturbs the phase of the trapping and tracking beam, such that the characteristic trajectories - obtained by interference and encoding the interactions - require a novel analysis method.

BP 17.48 Tue 18:00 P4

Investigating cell membrane tension — •Tina Boric[1,2], Julia Butzke[1,2], Eva Kreysing[2,3], and Kristian Franze[1,2,3] — [1]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [2]Institute of Medical Physics and Microtissue Engineering, Friedrich-Alexander-Universität, Erlangen-Nürnberg, Erlangen, Germany — [3]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, UK

Cellular membranes are known to change their mechanical properties in response to external and internal mechanical stimuli, such as shear forces and changes in tissue stiffness. Membrane tension contributes to the transduction of these mechanical signals into intracellular responses via mechanosensitive ion channels. However, how and if a change in tissue stiffness affects the surface mechanics of the cell, which in turn would contribute to the activation of mechanosensitive ion channels, is not yet known. We are investigating the dependence of the effective membrane tension of HEK 293T cells on the expression levels of the mechanosensor Piezo1 using optical tweezers. Furthermore, we are comparing tether forces of cells grown on compliant custom-made substrates of biologically relevant stiffness. We also expose the cells to different pharmacological treatments that primarily affect the actin cortex to investigate how membrane-to-cortex attachment affects tether forces. Ultimately, our aim is to understand how changes in membrane tension lead to the activation of Piezo1. Our work will contribute to the understanding of how mechanosensitive ion channels are gated, which may have important implications for drug design in the future.

BP 17.49 Tue 18:00 P4

Revealing minimal cell particle interactions by thermal noise frequency decomposition — •Max Wechlin, Felix Jünger, and Alexander Rohrbach — Lab for Bio- and Nano-Photonics, Department of Microsystems Engineering (IMTEK), University of Freiburg, Georges-Koehler-Allee 102, 79110 Freiburg, Germany

Nearly every interaction process in nano-scale soft materials, especially in living cells is governed by thermal noise. However, it is hardly known or often disregarded that many interaction processes take place only on specific timescales. This means that observing or measuring on the wrong timescale, can lead to wrong results or even no results. While interactions can be visible on one timescale, they can be completely invisible on another. Therefore, it is not only necessary to measure on a much broader frequency range than usually, but also to decompose the broadband fluctuation data with appropriate mathematical models. This way minimal or even hidden interactions can be revealed. We use optical tweezers based Photonic Force Microscopy with MHz-rate interferometric 3D particle tracking to approach 1*m-sized polystyrene beads to functional gels or to living cells. We demonstrate that interactions between particles and cells change in stiffness or friction over time and distance only on certain frequency bands, but not over the average fluctuations in energy and position.

BP 17.50 Tue 18:00 P4

Regulation of plasma membrane tension through the actin cytoskeleton and hydrostatic pressure — •Yogishree Arabinda Panda and Elisabeth Fischer-Friedrich — Excellence Cluster Physics of Life, TU Dresden, Dresden, Germany

The plasma membrane and its associated proteins serve as a critical signaling hub, transmitting information between the extracellular environment and the intracellular space. It plays essential roles in regulating the intracellular ion content, the membrane potential and processes such as endocytosis and exocytosis. Consequently, the plasma membrane is central to many physiological processes including cell differentiation, migration, and proliferation. Recent studies have shown that the activity of many transmembrane proteins is influenced by mechanical tension in the plasma membrane. Despite its importance in cellular signaling, the mechanisms by which cells regulate membrane tension remain poorly understood. In this study, we investigate the regulation of plasma membrane tension in mitotically arrested cells using FLIM in conjunction with the membrane dye FlipTR. Specifically, we explore how components of the actin cytoskeleton, intracellular hydrostatic pressure, and cell shape contribute to both actual and apparent membrane tension.

BP 17.51 Tue 18:00 P4

Single-cell physical phenotyping of blood and tissue biopsies — •Marketa Kubankova[1,2], Despina Soteriou[1,2], Martin Kräter[1,2], and Jochen Guck[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany

Deformability cytometry [1] is a microfluidic technique that allows the assessment of physical properties of single cells in a label-free and high-throughput manner, with up to 1000 cells analysed per second. Cell deformation and other physical phenotype parameters such as cell size and aspect ratio are obtained directly from brightfield cell images.

The diagnostic potential of deformability cytometry was previously demonstrated in various diseases [2, 3]. Here we show how deformability cytometry accurately discriminates between healthy and tumorous tissue in biopsies of mouse and human colons [4]. Cell deformation was a crucial parameter for the correct distinction of tumour tissue in colon cancer patients. Furthermore, we present new findings on how the physical properties of blood cells change during infectious diseases, and how they correlate with commonly used markers of infectious inflammation. Our findings pave the way for establishing deformability cytometry as a fast and marker-free diagnostic technique to sensitively detect pathological changes in solid and liquid biopsies.

[1] Otto et al., Nature Methods (2015), [2] Toepfner et al., Elife (2018), [3] Kubánková et al., Biophysical Journal (2021), [4] Soteriou and Kubánková et al., Nature Biomedical Engineering (2023)

BP 17.52 Tue 18:00 P4

Mechanobiology of immune cell confined migration — •Fatemeh Abbasi[1], Timo Betz[2], and Eva Kiermaier[1] — [1]LIMES Institute, University of Bonn, Bonn, Germany — [2]Third Institute of physics, University of Göttingen, Göttingen, Germany

In vivo, cells experience complex tissue environments and have to adjust their behavior and function based on their surrounding. Immune cells are the renowned examples. On their way from the bone marrow, where they are born, to the infection site, they have to cope with various physical challenges including geometrical confinement and different mechanical properties of the host tissues. To perform a successful confined migration, cells need to squeeze their nucleus, the most stiff and largest cell organelle, as well as reorganize their cytoskeleton. Despite the importance of this subject in immunology and pathology, it is still not well-understood how immune cells can adopt different nuclear morphologies and cytoskeleton organization while migrating through the small junctions and pores. Here, we use CFM (Confinement Force Microscopy), which was developed in the lab of Timo Betz, to confine immune cells in a 2.5D environment of various stiffness. We will study the role of centrosome, microtubule and nuclei morphology in innate immune cell confined migration. This study can help us to find out how nuclei and cytoskeletal organelles facilitate immune cell

migration through confined microenvironments of different mechanical properties. Simultaneous measurement of the cell forces on the microenvironment will enable us to find out the mechanobiology of immune cell confined migration.

BP 17.53 Tue 18:00 P4

Processivity of myosin assemblies: ATP dependence and effect on network dynamics — •Jaskaran Singh and Stefan Klumpp — University of Göttingen, Institute for the Dynamics of Complex Systems, Göttingen,Germany

Motors proteins like myosin, kinesin are a major source of activity in cellular mechanisms like cell division and perform tasks such as maintaining cellular structure and transporting cargo within the cell. These motors form complexes of multiple motors and cooperate and give rise to complex behaviors not seen in single-motor dynamics. Myosin motors form medium sized (˜100 motors) assemblies called myosin minifilaments that bind to and move along actin filaments. The mechanochemical cycle of individual motors in the motor assembly is dependent on ATP. We are exploring the concentration of ATP as a control parameter for the processivity (walking distance) of myosin minifilaments through stochastic modelling. Here we propose processivity as a parameter to tune the activity in system. On the cellular scale, we explore the effect of processivity on cytoskeletal network structures at large. Preliminary results show that decrease in ATP concentration increases the processivity of myosin assemblies. However, the velocity of motor assembly decreases with decreasing ATP. Thus, an optimal trade-off between processivity and velocity must be maintained for efficient assembly performance. To study the effect of processivity on network level structures, we use the simulation package Cytosim. The simulation shows that higher processivity leads to a more pronounced contraction of the actin network.

BP 17.54 Tue 18:00 P4

Mechanosensing and shape adaption of cells on substrates of varying stiffness — •Pooja Yadav, Florian Rehfeldt, and Matthias Weiss — Experimentalphysik I,University of Bayreuth

Changes of characteristic cellular features with varying stiffness of the underlying substrate, e.g. shapes and sizes of cells and nuclei, are a hallmark of the complex interplay of mechano-biochemical feedback loops. To explore this in detail, we have quantified cellular features on polyacrylamide (PA) hydrogels of varying stiffness, from 2∼kPa to 64∼kPa, hence mimicking the diverse micro-environments found in vivo. In particular, we have quantified the areas of nuclei and cells, their aspect ratio, and the local order parameter of the cytoskeleton on different substrates, also in the absence and presence of cytoskeleton-severing drugs. As a result, we observed that cell and nucleus areas follow an isometric relation with both areas increasing with the stiffness of the substrate. In contrast, the aspect ratio of both show a non-trivial maximum at intermediate stiffnesses, which we attribute to the local nematic ordering of the cytoskeleton. Altogether, our data open up the way to investigate differential mechanical effects of nuclei and cells under perturbations.

BP 17.55 Tue 18:00 P4

Mechanical properties of microtubule in actin network — •Komal Bhattacharyya, Sarah Köster, and Stefan Klumpp — University of Göttingen, Göttingen, Germany

The cytoskeleton provides structural support and facilitates dynamic cellular processes such as growth and migration. Actin and microtubules are key components of the cytoskeleton. Actin, characterized by its semi-flexible nature, contrasts with the stiff, rod-like structure of microtubules. The synergy between these two elements plays a pivotal role in numerous biological phenomena. For instance, microtubules exhibit enhanced resistance to compressive forces when integrated into an actin network.

In our research, we use the simulation package Cytosim to study composite networks formed by actin and microtubules. Specifically, we analyze the buckling behavior of microtubules under compressive forces and thermal fluctuations and how it is affected by mechanical coupling to actin. We observe that long-range repulsive interactions between the filaments lead to very small elasticity and minimal suppression of microtubule buckling. As a consequence, the observed mechanical responses within composite networks can very likely not be explained without considering specific interactions between actin and microtubules.

BP 17.56 Tue 18:00 P4

Mechanical Properties of Intermediate Filament Networks — •Jonas Penning and Stefan Klumpp — Institute for Dynamics of complex systems, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The mechanical strength and dynamics of cells are essential for sustaining life. For instance, during simple activities such as breathing or walking, cells are subjected to significant tensile stresses as they are stretched, sheared, or compressed. The cytoskeleton - a cross-linked composite network of actin, microtubules, and intermediate filaments - plays a central role in determining the cells' mechanical properties. While actin and microtubule networks have been studied extensively, this work focuses on intermediate filaments, such as vimentin and keratin. Compared to actin, intermediate filaments exhibit much smaller persistence lengths, but are much more stretchable with highly nonlinear elasticity. Extedning the freely-jointed chain (FJC) model by nonlinear stretching elasticity, a simplified model has been developed to investigate the mechanical and physical properties of cross-linked intermediate filament networks. Analogous to experimental approaches, the mechanical properties of the model are tested by applying normal and shear strains or stresses and analyzing the resulting responses.

BP 17.57 Tue 18:00 P4

Infrared Spectroscopic Analysis of Structural and Thermal Dynamics in Cytochrome c-DNA Complex — •Berken Hamarat, Damla Melisa Balci, and Günnur Güler — Biophysics Laboratory, Department of Physics, Izmir Institute of Technology, Izmir, Türkiye

Cytochrome c (Cytc) plays a crucial role in cellular respiration and apoptosis, with potential for biosensor applications due to its electron transfer capabilities. The binding of Cytc to DNA enables its consideration as a target molecule in biosensors and facilitates the modulation of Cytc's electronic properties via protein-DNA interactions. Temperature-controlled FT-IR spectroscopy in the transmission mode was used to investigate the structural changes and thermal stability of Cytc upon DNA complex in oxidized and reduced forms. Deuterated samples of Cytc and DNA were used during the analysis. Structural changes were observed after DNA binding, with a reduction in α-helix content, particularly in the oxidized form. Thermal stability analyses showed that the Cytc-DNA complex lost structural integrity at lower temperatures compared to free Cytc. These results indicate that DNA binding not only alters Cytc's secondary structure but also reduces its thermal stability. While Cytc's high thermal stability makes it suitable for biosensor applications, the observed changes after DNA binding, particularly the decrease in thermal stability must be minimized and optimized to ensure effective biosensor functionality. (Supported by Scientific and Technological Research Council of Türkiye, TÜBITAK 2209-B Project, 1139B412200835).

BP 17.58 Tue 18:00 P4

Soft-landing Electrospray Ion Beam Deposition (ES-IBD) allows integration of native mass spectrometry and cryoEM to investigate membrane protein structure and function — •Carl von Hallerstein, Sophie Lawrence, Tarick El-Baba, Stephan Rauschenbach, and Carol Vivien Robinson — Kavli Institute for Nanoscience Discovery, University of Oxford, UK

Electrospray Ion Beam Deposition (ES-IBD) is an emerging sample preparation for the imaging of molecules (Esser et al. 2022, Faraday Discussions). Recently, using native mass spectrometry (nMS), the deposition and cryo-electron microscopy (cryoEM) imaging of soluble proteins was demonstrated (Esser et al. 2024, Sci. Adv.).

Here, we apply ES-IBD + cryoEM to membrane proteins, which only retain their native state while encased in lipid membranes or membrane-mimetics such as detergents or nanodiscs. ESIBD+cryoEM yields valuable information on lipid and surfactant interaction as well as hydration of the membrane protein.

BP 17.59 Tue 18:00 P4

Investigation into the dynamic structure of heat shock proteins using electrospray ion beam deposition and cryo-electron microscopy (ESIBD+cryoEM) — •Noor Naseeb, Lukas Eriksson, Jingjin Fan, Justin Benesch, and Stephan Rauschenbach — University of Oxford, Oxford, United Kingdom

The heat shock protein (HSP) family encompasses a wide variety of polydisperse proteins that act as chaperones in the cell as a means of preventing aggregation and misfolding of proteins under different forms of cellular stress. Standard methods, like X-ray crystallography

(XRC), Nuclear magnetic resonance (NMR), and cryogenic electron microscopy (cryo-EM), lack the ability to properly study the structures of such dynamic and diverse proteins. To address this, we use electrospray ion beam deposition (ESIBD) that couples native mass spectrometry (MS), a chemically selective sample preparation technique, with cryo-EM. The combination allows for high-resolution visualization of a specific protein assembly by cryo-EM in their near-native state. Here we show that the chemically selective sample preparation technique via ESIBD enables structure determination of these dynamically assembled HSPs can be performed to better assess their structure, and therefore, function.

BP 17.60 Tue 18:00 P4

Hyperfine spectral diffusion in pulse EPR: theory and applications — •Sergei Kuzin[1,2], Gunnar Jeschke[1], and Maxim Yulkov[1] — [1]ETH Zurich, Zurich, Switzerland — [2]MPI for Multidisciplinary Sciences, G\"ottingen, Germany

Hyperfine interaction with nuclear spin bath and nuclear spin-spin interaction often dominate phase memory times of the electron spins in spin-diluted solids at cryogenic temperatures. Such an spin-ensemble effect also manifests is different EPR experiments as spectral diffusion.

Here, we present a new pulse EPR method called intermolecular hyperfine relaxation-induced dipolar modulation enhancement (ih-RIDME). This technique allows to investigate kinetics of spectral diffusion in amorphous solids. The sensitivity range of ih-RIDME lies within 1-3~nm around the spin centre. This makes it a powerful tool to probe nuclear spin arrangement at intermediate electron-nuclear distances. The quantification in ih-RIDME is based on a developed mathematical model of spectral diffusion resulting in a diffusion-like equation. With its help, ih-RIDME allows to quantify heterogeneous systems with a distribution of local proton densities.

We discuss the applications of ih-RIDME in dynamic nuclear polarization, structural biology, spin-labeled macromolecules and soft matter study.

BP 17.61 Tue 18:00 P4

Electron spin dynamics during MW pulses studied by 94 GHz chirp and phase-modulated EPR experiments — •Marvin Lenjer[1,2], Nino Will[3], Fabian Hecker[4], and Marina Bennati[1,2] — [1]MPI for Multidisciplinary Sciences — [2]Georg August University Göttingen — [3]Aarhus University — [4]Danish Technical University

Over the last decade, shaped microwave (MW) pulses have evolved into valuable tools for electron paramagnetic resonance (EPR) spectroscopy. They have been used to improve existing experiments by providing tunable broadband or band-selective frequency profiles as well as to design new experimental approaches. However, most applications were done at low fields (X- or Q-band) where high MW powers are available.

Here, we show the implementation of chirped and phase modulated pulses at a commercial Bruker E680 W-band (94 GHz) EPR spectrometer using a SpinJet arbitrary waveform generator. We apply these novel experimental tools to the analysis of spin dynamics during MW spin lock pulses. We measure inversion profiles in the intermediate regime between Rabi oscillations and saturation pulses via chirp echo EPR spectroscopy and analyze spin-spin relaxation during spin locking (i.e. $T_{2\rho}$) via phase modulation echoes during spin lock. Combination with density matrix simulations allows us to better understand electron spin evolution during long periods of MW irradiation. Altogether, these results promise future advances in design and applicability of hyperfine spectroscopy at high fields by use of spin locks and shaped pulses.

BP 17.62 Tue 18:00 P4

Human cardiac cadherin desmocollin 2 reveals ideal-, slip- and catch bonds in vitro — •Manuel Göz[1], Greta Pohl[2], Sylvia Steinecker[1], Volker Walhorn[1], Hendrik Milting[2], and Dario Anselmetti[1] — [1]Experimental Biophysics & Applied Nanoscience, Faculty of Physics, Bielefeld University, Bielefeld, Germany — [2]Heart & Diabetes Center NRW, University Hospital of the Ruhr-University Bochum, Bad Oeynhausen, Germany

Desmosomal cadherins like DSC2 are known to associate in a strand-swap binding motif in which an N-terminal tryptophan residue binds into the hydrophobic binding pocket of opposing cadherins. Although this binding pattern is highly specific, it is of low affinity and exhibits decreased bond lifetimes at a single-molecule level. Using AFM-based SMFS, we show that the strand-swap dimerized DSC2 has two further binding modes, which may play a role in the integrity of the cardiac muscle. At short interaction times, the DSC2 monomers associate only short-lived and force-independent. These ideal bonds are probably a precursor state that stabilizes the formation of the strand-swap dimer. Tryptophan added to the measurement buffer acts as a competitive inhibitor, preventing the N-terminal strand exchange. Here, DSC2 dimerizes as an X-dimer and shows a triphasic slip-catch-slip type of dissociation. Within a force-activated transition (catch) regime, DSC2 dimers switch between brittle low force and strengthened high force adhesion states. So we can assume that desmosomal adhesion is mediated not only by strand-swap dimers (slip bond) but also by their precursor states (ideal bond) and force-activated X-dimers (catch bond).

BP 17.63 Tue 18:00 P4

Trajectories of particles trapped in double well potentials show new behavior in the Mean Back Relaxation — •Christian Muñoz[1], Mohammad A. Eskandari[1], Bart E. Vos[1], Till M. Münker[1], Dorian Marx[1], Matthias Krüger[2], and Timo Betz[1] — [1]Third Institute of Physics - Biophysics, Georg August University Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Institute for Theoretical Physics, Georg August University Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Optical tweezers have been established as a powerful tool for studying microscopic particle dynamics in complex potentials. In this work, we investigate the behavior of a microparticle trapped in a double-well potential generated by optical tweezers. By systematically varying the laser power and the distance between the optical traps, we modeled the shape and depth of the potential. This approach allowed for a detailed analysis of the particle's stochastic transitions between the wells. Combining experimental measurements with Kramers' theory, we achieved accurate predictions of the transition rates between wells. Furthermore, we analyzed particle trajectories using the new quantity of Mean Back Relaxation (MBR), providing insights into the effects that a bistable system has on particle relaxation after defined fluctuations.

BP 17.64 Tue 18:00 P4

Cell-cell interactions of swimming ciliated microbes: from measured interaction dynamics to an effective potential — •Henrik Groh[1,2], Alexandros A. Fragkopoulos[1], Colin-Marius Koch[3], Michael Wilczek[3], and Oliver Bäumchen[1] — [1]University of Bayreuth, Experimental Physics V, 95447 Bayreuth, Germany — [2]University of Bayreuth, Experimental Physics I, 95447 Bayreuth, Germany — [3]University of Bayreuth, Theoretical Physics I, 95447 Bayreuth, Germany

In suspensions of living microorganisms the interactions of individual agents may result in large-scale collective effects. Frequently such phenomena are studied more extensively with the goal of linking them to the microscopic single-cell motility and cell-cell interactions. *Chlamydomonas reinhardtii* represents a unicellular eukaryotic model organism that is used to study collective phenomena of puller-type microswimmers, e.g., induced by a self-generated oxygen gradient [1] or by light (phototaxis). In order to complement these studies with a systematic cell-cell interaction analysis, we investigated the mutual interactions of *C. reinhardtii* in a quasi-2D suspension with high temporal and spatial resolution. Our measurements allow for deriving a pair-correlation function and an effective potential, which may eventually enter simulation studies. With our study we provide more detailed insights into the cell-cell interactions of *C. reinhardtii* and thus enable a better understanding of collective phenomena in living suspensions. [1] A.A. Fragkopoulos, et al., *J. R. Soc. Interface* **18**, 20210553 (2021).

BP 17.65 Tue 18:00 P4

Quantum Physics Meets Epigenetics: Does Nature Harness Charge and Energy Transfer in Methylated DNA? — •Dennis Herb[1,2], Mirko Rossini[1,2], and Joachim Ankerhold[1,2] — [1]Institute for Complex Quantum Systems, Ulm University, Germany — [2]Center for Integrated Quantum Science and Technology (IQST), Ulm-Stuttgart, Germany

Charge transfer processes through DNA play a crucial role in gene regulation, including processes such as DNA methylation, an epigenetic modification essential for gene expression. However, the effects of methylation on excitonic energy transfer (EET) and coherent charge transfer (CT) in DNA remain poorly understood. Here, we theoretically investigate the effects of DNA methylation, as well as conformational changes, on biologically relevant DNA sequences. Using a Linear Combination of Atomic Orbitals (LCAO) approach, we compute the molecular electronic structure of nucleic acid bases and derive parameters for a computationally efficient tight-binding (TB) model.

Our model incorporates intrinsic relaxation mechanisms for excited states, mimicking internal conversion (IC), and electron-hole Coulomb interactions. This framework provides physical insights into excited state lifetimes, charge separation dynamics, and dipole moments across diverse DNA sequences. By integrating quantum physics and physical chemistry methodologies with genetic and epigenetic analyses, this study offers a powerful interdisciplinary approach to investigate the quantum mechanisms underlying DNA charge dynamics and their modulation by epigenetic modifications.

BP 17.66 Tue 18:00 P4

Modeling host-pathogen interactions: infection process as a population dynamics problem — •Soham Mukhopadhyay[1], Jonathan Pollock[2], David Voehringer[2], and Vasily Zaburdaev[1] — [1]Department of Biology, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Department of Infection Biology, Uniklinikum Erlangen, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Helminth infections affect a large proportion of the world's population and cause significant morbidity. There are no vaccines against helminths, and the mechanisms by which the body fights off helminth infections are not well-understood. To better understand the immune system response we aim to develop a mathematical model describing the helminth load in different organs of the host as a function of time. As an experimental system, we use murine helminth infection by *Nippostrongylus brasiliensis*. We abstract infection progression as a state-transition process. The different host organs involved in the infection cycle act as the different states of the system, and the worms are treated as identical and independent particles transitioning from one state to another with fixed transition rates and delays. This allows simulation of the infection process via kinetic Monte Carlo and association of the infective dose of larvae to the number of eggs shed to the environment by adult worms from the intestine, which can then be compared against experimental data. Using simulations to generate training data, we employ Neural Network-based optimization to discover an optimal parameter set that can quantify the infection process.

BP 17.67 Tue 18:00 P4

Measuring activity from particle trajectories — •Lukas Abegg, Till M. Muenker, and Timo Betz — Third Institute of Physics, Georg August Universität Göttingen, Göttingen, Germany

Is it possible to distinguish activity from thermal fluctuations just from observed trajectories? The newly introduced statistical quantity Mean Back Relaxation aims to achieve exactly this by using three-point correlation functions. This non-dimensional function yields a measure for deviation from equilibrium within a confined system. It is calculated as the average displacement of a tracer article under the condition of having moved the distance d in advance. For an equilibrium process, this quantity results in a long time value of $\frac{1}{2}$. However, deviation from this value is a marker for broken detailed balance. To gain deeper insight into this new statistical measure, we investigate this quantity inside a controlled system, namely a viscoelastic polyacrylamide gel. This probe was tuned to imitate the mechanical properties of cells, containing polystyrene particles with a size of one micron. To drive this system out of equilibrium, we use a movable optical tweezer to simulate active motion of the particle. The Mean Back Relaxation is calculated for all trajectories and fitted with an analytical solution for a viscoelastic system. The results are used to quantify the diffusion coefficient of the trapping laser and thus, the activity of the system tuned by our experimental realisation. Additionally, we can calculate the shear modulus $G^\star$ from this result.

BP 17.68 Tue 18:00 P4

Active Soft Glassy Rheology as a model for cytoskeletal mechanics — •Raffaele Mendozza and Peter Sollich — University of Goettingen, Institute for Theoretical Physics

The cytoskeleton plays a vital role in cellular processes like growth, migration, and division, owing to its unique mechanical properties [1]. Advanced microrheology techniques have revealed a complex power-law viscoelastic spectrum in this and other biopolymer networks, reflecting the presence of a broad distribution of relaxation timescales [2]. Coarse-grained trap models capture this phenomenology, suggesting a connection between cytoskeletal and soft glassy rheology (SGR) [3,4,5]; however, the original SGR model lacks explicit consideration of active processes, ubiquitous in living cells. We therefore explore how activity influences the rheological response of a soft glassy material, based on different working hypotheses. By introducing an activity-dependent effective temperature, the characteristic SGR viscoelastic spectrum is recovered, while modelling activity as an effective strain rate introduces a competing timescale that modifies the response. The resulting active SGR model provides insights into the mechanical behavior of cells independent of biochemical intricacies, serving as a foundation for future models incorporating more detailed structural information.

[1] P. Kollmannsberger and B. Fabry, 2011
[2] B. Fabry et al., 2001
[3] B. D. Hoffman1 and J. C. Crocker, 2009
[4] K. K. Mandadapu et al, 2008
[5] P. Sollich et al, 1997

BP 17.69 Tue 18:00 P4

Fluctuating liquid inclusions morphology in biomolecular condensates driven by fuel-dependent binding agents — •Leonardo Silva-Dias and Christoph A. Weber — Universität Augsburg, Augsburg, Germany

The presence of aggregation-prone proteins in non-dilute, multi-component solutions, such as the cellular environment, can lead to the formation of protein aggregates. In these environments, such proteins may also undergo phase separation, forming biomolecular condensates. Both processes are regulated by specialized molecules known as binding agents, examples of which include RNA, enzymes, and chaperones. These binding agents continuously consume biological fuels, driving the system out of equilibrium and enabling the emergence of complex behaviors, such as morphological changes in the condensates. Specifically, recent experimental evidence has shown that a system composed of aggregation-prone proteins and ATP-driven chaperones induces the formation of condensates with a fluctuating liquid inclusions morphology. Based on these observations, the present work provides a theoretical framework to describe the emergence of the fluctuating liquid inclusions state. The proposed description is developed through a mean-field model that accounts for chemical reactions and phase separation in the presence of stochastic fluctuations. In this system, we observed that local fluctuations trigger multiple nucleation events within the condensates, leading to the growth of many liquid inclusion structures, which ripen, dissolve, and renucleate.

BP 17.70 Tue 18:00 P4

Competitive resource sharing mechanism for synchronization and its energy cost — •Dongliang Zhang[1,2], Yuansheng Cao[1], Qi Ouyang[3], and Yuhai Tu[4] — [1]Department of Physics, Tsinghua University, Beijing, China — [2]Max Planck Institute for the Physics of Complex Systems — [3]School of Physics, Zhejiang University, Hangzhou, China — [4]IBM T. J. Watson Research Center, Yorktown Heights, New York, USA

Synchronization among a group of active agents is ubiquitous in nature. Although synchronization mechanism based on direct pairwise interactions between agents as exemplified by the Kuramoto model is well understood. The dynamics and energetics of another general mechanism based on indirect interactions among agents sharing a limited resource are less known. In this work, we proposed a simple thermodynamically consistent model for the resource-sharing (RS) mechanism.We find that synchronization relies on differential competence of agents for the limited resources.More advanced agents are less competent, which provides a negative feedback mechanism resulting in synchronization. We show that differential affinity breaks detailed balance and thus synchronization requires continuous energy dissipation in addition to the energy cost of the agents* processive motion. Our study reveals a tradeoff relation between the total energy dissipation rate and the performance of the system characterized by its average speed and synchronization accuracy. Different Pareto fronts with fixed dissipation or speed result naturally from the Energy-Speed-Accuracy (ESA) relationship.

BP 17.71 Tue 18:00 P4

Time irreversibility and effective temperature are independently regulated in the actin cortex of living cells — •N Narinder and Elisabeth Fischer-Friedrich — Cluster of Excellence Physics of Life, Technische Universität Dresden, Dresden, Germany

Living cells exhibit non-equilibrium dynamics driven by the intricate interplay between motor activity and their viscoelastic environment. The deviation from thermal equilibrium termed as irreversiblity is commonly characterized by an increased effective temperature and time-reversal symmetry breaking quantified through the Kullback-Leibler divergence (KLD). In this study, we determine entropy production as

a measure of irreversibility both by the effective temperature and the KLD in the actin cortex of living cells using atomic force microscopy (AFM) with and without pharmacological treatments that modulate cellular activity and cortical mechanics. Surprisingly, we find that while the entropy production rate consistently increases with effective temperature, its time irreversibility estimated by the KLD can exhibit an opposite trend, depending on the mechanical properties of the cortex. Our findings underpin the role of mechanical properties on the irreversibility. Further, the findings are supported by a minimal model of the AFM tip as probe immersed in the viscoelastic environment of active cell cortex.

BP 17.72 Tue 18:00 P4

Triacylglycerols affect the water content and cohesive strength of collagen fibrils — •Martin Dehnert, Tiberius Klose, Yang Pan, Dietrich R. T. Zahn, Maximilian Voigtländer, Johannes F. Teichert, and Robert Magerle — Fakultät für Naturwissenschaften, Technische Universität Chemnitz, Germany

Collagens, lipids, and water are among the major molecular components of connective tissue, but surprisingly little is known about their interactions in vivo. Here, we provide direct evidence that type I collagen fibrils extracted from chicken calcaneal tendon contain triacylglycerols (TAG), which influence the water content of the fibrils and act as plasticizers that affect the mechanical properties of the fibrils. We use organic solvents to dissolve lipids from native collagen fibrils and identify them as TAG using Raman spectroscopy and NMR spectroscopy. Using atomic force microscopy-based 3D depth profiling, we quantify the changes in volume, water content, and indentation modulus of the fibrils caused by the removal of TAG at the single fibril level. Based on these findings, we propose a molecular model for the intercalation of TAG into collagen fibrils. The discovery of the biomechanical function of TAG is fundamental to understanding the role of lipids in collagen fibrils during development, aging, and disease.

BP 17.73 Tue 18:00 P4

Cellular Potts Model links tissue surface tension to cell proliferation — •Kai Lennard Fastabend[1], Cécile M. Bidan[2], John W. C. Dunlop[3], and Philip Kollmannsberger[1] — [1]Biomedical Physics, Heinrich Heine University Düsseldorf, 40225 Düsseldorf, Germany — [2]Max Planck Institute of Colloids and Interfaces, Dept. of Biomaterials, Golm, Germany — [3]Paris Lodron University, Salzburg, Austria

The shape and growth kinetics of tissue depend not only on biochemical factors but also on the geometry of the extracellular environment. Cellular Potts Model simulations of tissue growth on different substrate geometries are a promising approach to investigate the role of adhesion forces, cell elasticity and tissue surface tension in the formation and organisation of tissue. To investigate how tension-dependent cell proliferation in tissues can explain the observed link between scaffold geometry and tissue growth kinetics, we implemented a growth rule based on the stretching of cells in CompuCell3D. Systematic parameter scans reveal the role of cell-substrate adhesion as the driving factor for monolayer formation, while cortical contractility introduces a surface tension to the tissue. The minimization of the macroscopic tissue surface leads to bulk tissue growth beyond the monolayer depending on the underlying substrate geometry. Our results highlight how cellular contractility and adhesion, together with geometric boundary conditions can determine the macroscopic growth patterns of tissues, independent of soluble growth factors.

BP 17.74 Tue 18:00 P4

Nanomechanical ultrastructure of native tendon tissue — Mario Zerson, Martin Dehnert, Paul Zech, Tiberius Klose, and •Robert Magerle — Fakultät für Naturwissenschaften, TU Chemnitz

Tendon tissue is a natural, high performance material in which type I collagen fibrils act as the load-bearing elements. The collagen fibrils are embedded in the tendon ground substance, a hydrophilic gel. Using AFM-based nanoindentation measurements, we study the nanomechanical ultrastructure of collagen fibrils in native tendon tissue obtained from the calcaneus (Achilles) tendon of chicken. The sample is exposed to a flow of humid air with controlled relative humidity to maintain the water content close to physiological conditions. We reconstruct 3D depth profiles from measured force–distance data and analyze the tip–sample interaction with a recently developed hysteresis model with return point memory (Soft Matter 2024, *20*, 2831–2839). The latter describes the rate-independent nanoindentation response, which is dominated by an elasto-plastic deformation behavior. It allows us to quantify the elastic and dissipative contributions of the indentation response within individual collagen fibrils as well as in the contact regions between adjacent fibrils.

BP 17.75 Tue 18:00 P4

Adjustable tension in reconstituted heart muscle tissue to mimic physiological mechanical environment changes — •Anna Mukhina[1], Till Muenker[1], Mattias Luber[1], Arne Hofemeier[2], Bruno Schmelz[1], and Timo Betz[1] — [1]Third Institute of Physics - Biophysics, University of Goettingen — [2]Department of Pharmacology and Toxicology, University Medical Center Goettingen

The development of in vitro 3D muscle tissues is critical for studying muscle physiology, disease mechanisms, and drug responses. PMMA tissue chambers provide structural support for myogenic cells embedded in a 3D ECM scaffold, enabling organization into aligned myotubes resembling natural muscle tissue. Tissue self-organizes around posts of known stiffness, with muscle strength assessed via post-deflection during contraction. This project introduces a piezo-driven actuator into the PMMA chamber for external manipulation of tissue tension. Combining actuators with a direct readout of posts' positions enables feedback control to emulate diverse mechanical environments. This innovation investigates how varying mechanical loads influence muscle development, adaptation, and therapeutic responses.

The project involves: (1) design and integration of a piezo actuator system, using CAD and Labview for construction and feedback control; (2) validating the modified chamber with engineered human myocardium (EHM) derived from iPSCs, exposed to defined mechanical stresses to mimic physiological and pathological loads. Functional and morphological outcomes are assessed via post deflection analysis and fluorescence imaging, advancing insights into muscle biomechanics.

BP 17.76 Tue 18:00 P4

Illuminating forces in living tissues — •Lucia Baldauf[1], Anna Bajur[2], Katelyn Spillane[2], and Guillaume Charras[1] — [1]London Centre for Nanotechnology, University College London, UK — [2]Department of Life Sciences, Imperial College London, UK

How can epithelial tissues withstand large forces and support deformations that drastically increase their length? Adult epithelial tissues regularly experience forces that stretch them by up to 50 %, and deformations can reach several hundred percent during development. To fulfill their physiological barrier function, epithelia must accommodate such large deformations without fracturing. Consequently, cell-cell adhesions must be finely tuned, or pathologies like skin blistering or cancer metastasis can occur. However, the physical principles governing tissue integrity remain difficult to study, since tissue fracture is a multiscale process spanning up to 10 orders of magnitude in both size and force. Millimetre-sized tissues can withstand millinewton-forces, but tissue fracture results from the local failure of single nanometre-sized adhesion complexes that bear piconewton forces. New tools are needed to bridge these vastly different scales and understand what molecular processes lead to tissue failure. Here we develop a new experimental tool to study tissue integrity and force propagation across scales. We engineer living model tissues where DNA-based molecular force sensors in chimeric cell-cell junctions provide a local molecular-scale force readout, for the first time illuminating how forces propagate in living tissues under stretch.

BP 17.77 Tue 18:00 P4

Imaging cell mechanics of retina organoids using an oblique plane light-sheet microscope — •Achim Theo Brinkop[1,2], Florian Schorre[1], Stefan Stöberl[1], Elijah R. Shelton[1], Teresa Rogler[1,2], Michael Frischmann[1,2], Marie Lackmann[1], Kaustav Goswami[1], Alexander Zangl[1], Mythili Padavu[1], and Friedhelm Serwane[1,2,3] — [1]Faculty of Physics & Center for NanoScience, LMU Munich, Germany — [2]Institute of Biophysics, Ulm University, Germany — [3]Munich Cluster for Systems Neurology (SyNergy) & Graduate School of Systemic Neuroscience (GSN), Munich, Germany

Retina organoids have become a powerful testbed for studying retina formation and neuronal development. Our current measurements of the creep compliance in retina organoids with magnetic droplets point towards soft glassy rheology of developing retinal tissue at second to hour timescales. As a next step, we explore whether the motion of cells agrees with predictions for glassy materials. For this purpose, we built a custom oblique plane microscope for long-term volumetric imaging of the cell movements during organoid development. Using a processing pipeline based on open-source python packages (Cellpose3, Ultrack),

we segment and track individual cells. The tracks allow us to quantify cell dynamics and compare these with existing models for glassy materials. In the future, we will integrate magnetic droplet compliance measurements with volumetric imaging in one set-up to simultaneously probe organoid mechanics *in situ*. Combining tissue mechanics measurements with cell dynamic recordings, we aim to shed light on the mechanical cues that guide retina formation.

BP 17.78 Tue 18:00 P4

Investigating the mechanosensitive expression of sema3A and slit1 in hydrogel-embedded neuroepithelial cells — •Niklas Gampl[1,2] and Kristian Franze[1,2,3] — [1]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [2]Institute of Medical Physics and Microtissue Engineering, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany — [3]Department of Physiology, Development and Neuroscience, University of Cambridge, Cambridge, UK

During brain development, neurons extend long axons that grow along well-defined pathways to their destination. This axon pathfinding is regulated by chemical guidance cues, which are produced by neuroepithelial cells, and by tissue stiffness. To investigate whether environmental stiffness regulates the expression of chemical guidance cues in the developing brain, we developed a framework to culture Xenopus tissue explants in collagen-based hydrogels with tunable stiffness. We found an increase in sema3A and slit1 mRNA levels in hypothalamic neuroepithelial tissue cultured in stiff hydrogels (G' = 450 Pa) compared to soft hydrogels (G' = 40 Pa). Additionally, 3D traction force microscopy revealed that strain energy, generated by the explants and stored in the matrix, increased with stiffness. These findings highlight a mechanochemical mechanism linking tissue stiffness to chemical guidance cue expression. Further investigation could improve our understanding of the complex interplay between guidance cues and their integration by cells.

BP 17.79 Tue 18:00 P4

AFM imaging of epithelial basement membrane with and without molecular perturbations — •Karla Yanin Guerra Santillan[1], Christian Dahmann[2], and Elisabeth Fischer-Friedrich[1] — [1]Cluster of Excellence Physics of Life, Technische Universit\"at Dresden, Dresden, Germany — [2]School of Science, Technische Universit\"at Dresden, Dresden, Germany

Understanding the precise regulation of growth and form is fundamental to the healthy development of all organisms. The basement membrane is a specialized sheet of extracellular matrix that forms at the basal face of epithelial tissues. This biopolymer network plays a major role in structural support, proliferation regulation and biochemical signalling. Here, we present data of high-resolution images of the basement membrane in developing wing discs of the fruit fly Drosophila melanogaster using atomic force microscopy. We find that depending on the developmental stage, micron-sized ripple patterns of different amplitude are present on the surface of the basement membrane that depend on the presence of individual ECM proteins.

BP 17.80 Tue 18:00 P4

Species-specific biomineral pattern formation in centric diatoms — •Francesco Leone[1], Nils Kröger[1,2], and Benjamin M. Friedrich[1] — [1]Physics of Life, TU Dresden, 01307 Dresden — [2]B CUBE, TU Dresden, 01307 Dresden

Diatoms are unicellular algae known for their intricately patterned cell walls, primarily composed of amorphous silica (SiO2). Their hierarchically patterns biomineral architectures display outstanding material properties but also represent an ideal model system to study species-specific pattern formation during biomineralization by living organisms. In centric "barrel-shaped" diatoms, the "lids" display three prominent pattern features: branched rib patterns with radial symmetry, nano-pores and transverse connections. How these different pattern features evolve and mutually influence each other is not known. We are extending a mathematical model of branching morphogenesis, previously developed in our group for a single model species [1], to account for the variety of patterns in related species and mutants. To facilitate a rigorous quantitative comparison to electron microscopy images, we are developing automated image analysis pipelines for the morphometric characterization of different phenotypes. Through this research, we aim to reverse-engineer putative chemical and physical mechanisms taking place during diatom silica cell wall formation.

[1] Babenko et al. PNAS 121(10): e2309518121 2024

BP 17.81 Tue 18:00 P4

Self-stimulated growth of epithelial model tissues — •Maja Milas[1], Damir Vurnek[2], Narmin Abasova[2], Kevin Höllring[2], and Ana-Sunčana Smith[1,2] — [1]Group for Computational Life Sciences, Division of Physical Chemistry, Ruđer Bošković, Institute, Zagreb, Croatia — [2]PULS Group, Center for Advanced Materials and Processes, FAU Erlangen-Nürnberg

The growth of epithelium is one of the fundamental biological processes required for sustaining the life of multicellular organisms. This process can be studied in appreciable detail using model systems such as radially growing 2D MDCK colonies. Typically, epithelium grows from low densities to the homeostatic state while expanding laterally. This process has, in the past, been captured using Fisher Kolmogorov-like growth laws, where shortly after the establishment of homeostasis, the moving front reaches a constant velocity and density profile. However, in experiments presented herein, we show that the moving front continues to accelerate and expand for days after the steady state density is achieved in the center of the colony. This radial expansion cannot be captured by currently established models, even after introducing a highly non-linear growth term and recently proposed delays. We can, nonetheless, rationalize this growth scenario by introducing self-stimulation by an activator secreted and absorbed in a density-dependent manner and coupling it with the equation for the evolution of the density. Further work is necessary to identify the biochemical pathway regulating the effect of the activator.

BP 17.82 Tue 18:00 P4

Epithelial Tissue Response Under Solid Shear Stress — •Narmin Abasova[1], Annemarie Wirth[1], Kevin Hoellring[1], Rudolf Merkel[2], and Ana-Sunčana Smith[1,3] — [1]PULS Group, Institute for Theoretical Physics, FAU Erlangen- Nurnberg (IZNF) — [2]Institute for Biological Information Processes (IBI), Forschungszentrum, 52428 Jülich, Germany — [3]Group of Computational Life Sciences, Division of Physical Chemistry, Ruder Bošković Institute, 10000 Zagreb, Croatia

Epithelial cells are subjected to a diverse range of mechanical stresses in the human body, from the dynamic forces generated during physical activity to the rhythmic pulsations of blood flow. To better understand the mechanobiological processes due to various stress types, it is essential to investigate how they influence cellular responses and tissue functionality. Among the different forms of mechanical stress, solid shear stress transmitted through the extracellular matrix (ECM) remains a relatively underexplored side of tissue mechanics. Our research addresses this gap by utilising a custom-designed device that applies controlled shear stress to the substrate supporting epithelial cell cultures. By subjecting targeted cell clusters to solid shear stress, we observe and document the tissue's behavior under a microscope. This study examines key aspects of cellular response, including stress relaxation, proliferation, morphological alterations and topological changes at cell membranes, where neighboring cells exchange positions. Using stress-generating devices in this context allows us to better understand how distinct stress types influence tissue behavior.