BP 36: Cell Mechanics II

Time: Friday 10:00–13:00 Location: H 0112

BP 36.1 Fri 10:00 H 0112

Optical Cavities for Biology — •Maerpreet Kaur Arora[1,2], Florian Steiner[1,2], and Thomas Hümmer[1,2,3] — [1]Ludwig-Maximilians-University Munich, Department of Physics, Munich, Germany — [2]Qlibri GmbH, Munich, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

Label-free imaging of bio-molecules in combination with absorption spectroscopy is essential for observing mechanisms in real time. Analysis of absorption properties for sub-cellular structures is challenging due to their weak interaction with light. Fiber-mirror optical cavities strongly enhance this interaction and enable direct imaging and absorption characterization of nano-scale samples.

To this end, the analysis of cavity properties in the natural environment of these biological samples is crucial. We observe the parameter changes of the cavity in water and air and compare them to simulated data.

BP 36.2 Fri 10:15 H 0112

Electromagnetic field stimulation (EMS) rescues defects in axonal organelle trafficking, regeneration and DNA damage response (DNA-DR) in amyotrophic lateral sclerosis (ALS) — •Arun Pal, Jens Pietzsch, and Thomas Herrmannsdörfer — Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

Cellular events benefit from EMS with alternating fields (AC). Our in vitro experiments on cultured compartmentalized iPSC-derived spinal motoneurons from familiar ALS patients aim to reveal the optimal magnetic field configuration with respect to the AC frequency, amplitude and orientation. Following EMS, we analyzed its impact on axonal organelle trafficking, regeneration after axotomy and DNA-DR in the nucleus by live-cell imaging. All three readout assays are clinically relevant for neurodegeneration and revealed clear defects in our ALS neurons. Beyond a critical threshold of field strength, we found a sustained rescue of the motility of axonal mitochondria and lysosomes along with increased outgrowth speed of growth cones after axotomy and a re-activated DNA-DR through AC sine waves at perpendicular field orientation to the axonal plane with a special frequency optimum. Our results point to a powerful non-invasive and non-pharmacological novel therapeutic method. Thus, we are prototyping a patient stretcher with multiple arrayed built-in magnetic coils to expose all body parts to vectorized magnetic fields of any spatiotemporal modulation for the treatment of neurodegenerative diseases. The coils can be operated either in a continuous AC mode or with repetitive pulses by discharging a capacitor bank.

BP 36.3 Fri 10:30 H 0112

Coordinated poleward flux of sister kinetochore fibers drives chromosome congression — •Domagoj Božan[1], Jelena Martinčić[2], Patrik Risteski[2], Nenad Pavin[1], and Iva Tolić[2] — [1]Department of Physics, Faculty of Science, University of Zagreb, Bijenička cesta 32, 10000 Zagreb, Croatia — [2]Division of Molecular Biology, Rudjer Bošković Institute, Bijenička cesta 54, 10000 Zagreb, Croatia

Chromosome congression and alignment at the spindle equator promote proper chromosome segregation and depend on pulling forces exerted at kinetochore fiber tips together with polar ejection forces. However, kinetochore fibers are also subjected to forces exerted by motor proteins that drive their poleward flux. Here we introduce a flux-driven centering model that relies on flux generated by forces within the overlaps of bridging and kinetochore fibers. This centering mechanism works so that fewer longer kinetochore fibers fluxes faster than the greater number of shorter ones, moving the kinetochores towards the center. We compare this model with the results of speckle microscopy performed by our collaborators and obtain good correspondence with the experiment. Thus, length-dependent sliding forces exerted by the bridging fiber onto kinetochore fibers promote chromosome congression and alignment.

BP 36.4 Fri 10:45 H 0112

An oblique plane light-sheet microscope for volumetric imaging of neural signals and *in situ* sample manipulation — •Achim Theo Brinkop[1], Stefan Stöberl[1], Florian Schorre[1], Rebecca James[1], Lena Glanz[1], and Friedhelm Serwane[1,2,3] — [1]Faculty of Physics & Center for NanoScience, LMU Munich, Germany — [2]Munich Cluster for Systems Neurology (SyNergy), Germany — [3]Graduate School of Systemic Neuroscience (GSN), Munich, Germany

Many biophysical applications require high-speed volumetric imaging with open top access, e.g. long-term imaging of living organisms and sample manipulation. Existing microscope set-ups, however, are complex or tailored to specific applications. To investigate both mechanical and electrical properties of neural organoids, we designed and built a high-speed oblique plane microscope using one objective for illumination and detection. The set-up allows for imaging genetically encoded calcium and voltage indicators. At the same time, it is compatible with the use of magnetic actuators which can be mounted above the sample to probe the tissue's mechanical properties *in situ*. First measurements show a signal-to-noise ratio on the order of 10 for Ca^{2+}-imaging inside neural organoids at a single-cell level for exposure times of milliseconds. With this set-up, we aim to gain a deeper understanding of 3D organoid neuronal network formation and function.

BP 36.5 Fri 11:00 H 0112

Electron UHDR and FLASH radiation biology studies at PITZ, DESY — •Yuliia Komar[1,2], Anna Grebinyk[1,2], Marcus Frohme[1], Frank Stephan[2], Zakaria Aboulbanine[2], Namra Aftab[2], Zohrab Amirkhanyan[2], Aida Asoyan[2], Prach Boonpornprasert[2], Paul Borchert[1], Hakob Davtyan[2], Dmytro Dmytriiev[2], Georgi Georgiev[2], Matthias Gross[2], Andreas Hoffmann[2], Mikhail Krasilnikov[2], Xiangkun Li[2], Max Liebel[2], Zahra Lotfi[2], Frieder Mueller[2], Anne Oppelt[2], Aleksandar Radivoievych[1], Chris Richard[2], Felix Riemer[2], Houjun Qian[2], Grygorii Vashchenko[2], and Daniel Villani[2] — [1]Technical University of Applied Sciences Wildau, Wildau, Germany, — [2]Deutsches Elektronen-Synchrotron, Zeuthen, Germany

The Photo Injector Test facility at DESY in Zeuthen (PITZ) together with the Technical University of Applied Sciences Wildau are going to study ultra-high dose rate (UHDR) cancer radiation therapy (RT) at FLASHlab@PITZ. FLASH RT is based on UHDR irradiation (40-10^9 Gy/s) and was shown to have a higher sparing effect on normal tissue in comparison to conventional dose rate (0.05 Gy/s) applied in clinics. The unique parameter space of the PITZ beam allows to deliver dose rates in the range between 0.05 Gy/s and 10^14 Gy/s, providing a unique possibility to investigate the effect of dose rate escalation and contribute to widening of the RT therapeutic window. For that matter, the in vitro effect of UHDR was studied at FLASHlab@PITZ. The obtained data demonstrated ROS generation, DNA damage and cell proliferation decrease at increasing doses for both UHDR 10^5 Gy/s and conventional 0.05 Gy/s. The obtained first results highlighted the potential to explore UHDR further for cancer RT.

BP 36.6 Fri 11:15 H 0112

Electrohydraulics of electrically polarized spherical organoids — •Amit Singh Vishen[1], Ahandeep Manna[1], Jacques Prost[2], and Frank Julicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Laboratoire Physico-Chimie, Institut Curie, Paris, France

Cells and tissues in many contexts are electrically polarized. We develop a three-dimensional electro-hydraulic model that simultaneously solves for the electric potential, ion concentration, and hydrodynamic flows and stresses inside and outside a spherical water-filled cavity enclosed by an epithelium. We analyze two sources of electric asymmetry in the system: (i) heterogeneous ion transporter along the surface of the sphere and (ii) organoid in an external electric field. We show that inho- mogeneous ion transport leads to an organ-scale electric current and water flux. Consistent with recent experimental observation we find that a constant electric field leads to isotropic swelling of the organ.

15 min. break

BP 36.7 Fri 11:45 H 0112

Light-Induced Chloroplast Morphodynamics in a Single Celled Algae — •Nico Schramma, Gloria Casas Canales, and Maziyar Jalaal — Van der Waals-Zeeman Institute, University of Amsterdam, Amsterdam, Netherlands

Photosynthesis is essential for all life on Earth. However, the ever-changing light conditions in the environment of immobile organisms are continuously challenging the photosynthetic performance. A vast amount of photosynthesis takes place in the ocean and even simpler forms of life, such as the non-motile single-celled marine algae Pyrocystis lunula, can adapt to changes of light by moving their chloroplasts. As this process occurs in confinement by the rigid cell wall, the drastic intracellular re-arrangement needs "smart" logistics strategies. Here we uncover that the cell exploits meta-material properties to efficiently adapt to such environmental changes. Exposing the cell to different physiological light conditions and applying temporal illumination sequences shows that the morpho-dynamics follow simple rules. This kind of dynamic testing allows us to extract the coarse-grained equations of motion to describe this biological system. Our study shows how topologically complex metamaterials are applied in critical life-sustaining processes in nature and that simple dynamical rules can account for complex material transport in a crowded intracellular environment.

BP 36.8 Fri 12:00 H 0112

Band pattern formation in a suspension of red blood cells during centrifugation in a Percoll density gradient — •Felix Maurer, Thomas John, Christian Wagner, and Alexis Darras — Saarland University, 66123 Saarbrücken, Germany

Percoll is a suspension of silica nanoparticles often used to establish density gradients and separate biological matter in centrifugation protocols. When red blood cells (RBCs) sediment in a Percoll medium, they form patterns of discrete bands. While this is a popular approach for RBC age separation, the mechanisms involved in band formation were unknown. In a series of experiments we could show that the formation of those patterns could be explained by cell aggregation. We developed a new continuum model to describe the volumetric RBC density under the influence of attractive pair interaction. Our numerical solutions are characterized by pattern formation and transitions between the equilibrium states depending on aggregation energy and initial volumetric RBC concentration.

BP 36.9 Fri 12:15 H 0112

Unraveling the dynamics of *Trypanosoma brucei*: a microfluidic approach — •Hannes Wunderlich[1], Sebastian W. Krauss[1], Lucas Brehm[2], Marinus Thein[2], Klaus Ersfeld[2], and Matthias Weiss[1] — [1]Experimental Physics I, University of Bayreuth, Germany — [2]Molecular Parasitology, University of Bayreuth, Germany

Trypanosoma brucei is a unicellular parasite that causes the African sleeping sickness after transmission by tsetse flies. These microswimmers use a single microtubule-driven flagellum for their helical forward motion, which is essential for the virulence and survival of the parasite. A highly ordered subpellicular microtubule array equips the cell with a considerable bending elasticity. However it is unclear how this elasticity relates to the cell's propulsion.

Using microfluidic devices, we have studied the swimming of wild-type trypanosomes and mutant strains in which post-translational modificiations of microtubules have been altered. First, trypanosomes were allowed to move freely in 2D chambers, from which a run-and-tumble motion and the effective velocities of individual cells were extracted and compared. When encapsulating single trypanosomes in droplets of similar size, a purely rotational motion emerged. While each cell showed a mostly persistent (counter-)clockwise rotation, no directional preference was seen on the ensemble level. Monitoring the angular motion over extended periods revealed again a run-and-tumble behavior. The planar and angular velocities depended on the cell's elasticity. Our results suggest that an effective propulsion requires a distinct elasticity of the subpellicular microtubule array.

BP 36.10 Fri 12:30 H 0112

Red blood cell lingering: impact on microcirculation hematocrit distribution and differences in rigid versus healthy cells — •Yazdan Rashidi[1], Selina Wrublewsky[2], Felix Maurer[1], Khadija Larhrissi[1], Thomas John[1], Lars Kaestner[1], Matthias W. Laschke[2], Michael D. Menger[2], Christian Wagner[1], and Alexis Darras[1] — [1]Experimental Physics, Saarland University, 66123 Saarbrücken, Germany — [2]Institute for Clinical and Experimental Surgery, Saarland University, 66421 Homburg, Germany

The distribution of red blood cells (RBCs) in the microcirculation determines how the oxygen is delivered to tissues and organs. This process relies on the partitioning of RBCs at successive microvascular bifurcations. Usually, downstream of a microvascular bifurcation, the vessel branch with a higher fraction of blood flow receives a higher fraction of RBC flux. However, both temporal and time-average deviations from this phase-separation law have been observed in recent works. Here, we quantify how the microscopic behaviour of RBCs lingering (i.e. RBCs temporarily residing near the bifurcation apex with diminished velocity) influences their partitioning, through combined in vivo experiments and in silico simulations. We developed an approach to quantify the cell lingering at highly confined capillary-level bifurcations and demonstrate that it correlates with deviations of the phase-separation process from established empirical predictions by Pries et al. Furthermore, we shed light on how the bifurcation geometry and cell membrane rigidity can affect the lingering behaviour of RBCs, and show rigid cells tend to linger less than softer ones.

BP 36.11 Fri 12:45 H 0112

Lightmicroscopy of Red Blood Cells — •Agatha Belén Pinto-Pino, Sarah Tabea Hermes, Thomas John, and Christian Wagner — Campus E2.6 66123 Saarbrücken

The observation of cells in liquids under a conventional light microscope is a common practice in research. Because the refractive index within the cells is greater than in the medium, refraction also takes place in addition to absorption. The resulting microscope image is therefore a composition of absorption and refraction as a function of the set focal plane. This is very important for the detection of the cell edges and thus the cell morphology [1]. Using the example of red blood cells, we show how refraction leads to "ghost edges" and compare this with numerical simulations of the light paths. Surprisingly, the optimal focus is not the position with the highest contrast. We give further hints for the optimal observation of red blood cells.

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