BP 55: Cell Migration and Contraction

Time: Thursday 15:00–17:15 Location: HÜL 386

Invited Talk BP 55.1 Thu 15:00 HÜL 386

Network heterogeneity regulates steering in actin-based motility — •Laurent Blanchoin — CytoMorphoLab, Biosciences & Biotechnology Institute GRENOBLE, FRANCE

The growth of branched actin networks powers cell-edge protrusions and motility. These dynamic structures are characterized by a heterogeneous actin density, which yields to a tunable cellular response. We studied how actin organization controls both the rate and the steering during lamellipodium growth. We used a high-resolution surface structuration assay combined with modeling approach to describe the growth of a reconstituted lamellipodium. We demonstrated that local monomer depletion at the site of active assembly negatively impacts the network growth rate. At the same time, network architecture tunes the protrusion efficiency, and regulates the rate of growth. One consequence of this interdependence between monomer depletion and network architecture effects is the ability of heterogeneous network to impose steering during motility. We established therefore the general principles on how the cell can modulate the rate and the direction of protrusion locally by varying both density and architecture of its actin network.

BP 55.2 Thu 15:30 HÜL 386

Collective cell migration on soft substrates — •Andriy Goychuk and Erwin Frey — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität, München, Deutschland

The extracellular matrix surrounding cells strongly influences their migratory behavior. This includes the decrease of cell proliferation with the substrate stiffness. To better understand this phenomenon, we study a modified Cellular Potts Model on a deformable hexagonal lattice. The cell polarization and cytoskeletal remodeling is simulated by a coarse-grained routine on a sub-cellular level. We show that cells exhibit a fast and persistent motion in the higher range of substrate stiffness, unlike in the lower range. In the intermediate regime, the cells show more complex behavior and move in groups.

BP 55.3 Thu 15:45 HÜL 386

Time-Resolved Measurement of Highly Dynamic Force Evolution in Small Cells — •Jana Hanke[1], Dimitri Probst[2], Ulrich S. Schwarz[2], and Sarah Köster[1] — [1]Institute of X-Ray Physics, University of Göttingen, Göttingen, Germany — [2]Institute for Theoretical Physics and BioQuant, Heidelberg University, Heidelberg, Germany

Force generation is an important aspect in numerous essential biological processes like rigidity sensing, spreading and motility. Measuring such forces as they are exerted on the cellular environment at high spatial resolution and in a time-resolved manner remains a challenge. Here we optimise traction force microscopy on soft elastic substrates for measurements of human blood platelets, which generate comparatively high traction forces although they are the smallest cells in the human body. By tracking force evolution over 30 minutes, we characterise the cells' highly dynamic force development on substrates of 19 to 83 kPa stiffness. Independent of the stiffness, we find three distinct behaviours in individual cells, namely platelets reaching a force plateau, as well as a relaxing or oscillatory behaviour after initial contraction. The average initial contraction velocity, however, is dependent of the stiffness as it increases with increasing stiffness.

BP 55.4 Thu 16:00 HÜL 386

Combined MEA- and SICM-based measurements of the cardiomyocyte contractile behavior — •Stefan Simeonov and Tilman E. Schäffer — Institute of Applied Physics, University of Tübingen, Germany

We present a novel experimental setup that combines microelectrode array (MEA) based electrical recording with scanning ion conductance microscopy (SICM). MEAs are used for non-invasive, in-vitro measurements of extracellular electrophysiological signals generated by live cells. SICM is a non-invasive scanning probe technique for imaging sample topography with sub-micrometer spatial resolution. We used this combined setup to investigate beating cardiac cells (HL-1 cell line), which exhibit both electrophysiological activity and morphological dynamics. We mapped the height of a beating cell as a function of time with sub-cellular spatial and millisecond temporal resolution. Synchronizing the SICM data with the simultaneously recorded extracellular field potential from the MEA allowed us to reconstruct the time-resolved 3D topography during the contraction and relaxation cycle of the cell. Furthermore, we investigated the effect of blebbistatin, a myosin II motor protein inhibitor, on the contractile behavior of beating cells. The contraction amplitude decreases over time until the cells stop contracting entirely despite the ongoing generation of unaltered extracellular field potential.

15 min break

BP 55.5 Thu 16:30 HÜL 386

Variability, order and myosin II acceleration of cortical dynamics of motile amoeboid cells — Hsin-Fang Hsu[1], Eberhard Bodenschatz[1], Alexei Krehkov[1], Christian Westendorf[1], Azam Gholami[1], Alain Pumir[2], •Marco Tarantola[1], and Carsten Beta[3] — [1]MPI-DS, Am Fassberg 17, D-37077 Göttingen — [2]Laboratoire de Physique, Univ Lyon, ENS, CNRS, F-69342 Lyon — [3]Institute of Physics and Astronomy, Univ Potsdam, D-14476 Potsdam

Chemotactic motion of cells relies on membrane protrusions driven by the polymerization and depolymerization of actin. Here we show that the response of the actin system of Dictyostelium discoideum (D.d.) to a receptor stimulus is subject to a threshold value that varies strongly from cell-to-cell. Above threshold, we observe pronounced variability in response amplitudes. Polymerization time, however, is almost constant over the entire range of response amplitudes, while depolymerization time increases with increasing amplitude. We show that cell-to-cell variability in the response amplitude correlates with the amount of Arp2/3, a protein that enhances actin polymerization. Another key player governing dynamics of the actin network is the motor protein myosin II. Upon chemotactic stimulation, myosin II is first released from the cell cortex but then relocates to the cortical region with actin filaments. Using Poincaré mapping, we analyze the detailed dynamical interplay of actin, myosin II and the cell area. Cells lacking myosin II show a deceleration of cortical actin recovery after stimulation, suggesting the important role of myosin II in setting the response time.

BP 55.6 Thu 16:45 HÜL 386

Transport of micro-cargo by amoeboid cells — •Oliver Nagel, Manuel Frey, Valention Lepro, Matthias Gerhard, and Carsten Beta — Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany

The directed transport and positioning of micron-sized objects in complex confined geometries is difficult to achieve and often relies on laborious techniques, such as magnetic or optical tweezers, or microsurgery. Here, we propose a alternative approach based on the idea to harness motile amoeboid cells as trucks that transport micro-cargo to desired locations. We show that cells of the social amoeba *Dictyostelium discoideum* can transport micro-particles with a wide range of different sizes. The cells can be guided by gradients of the chemoattractant cAMP, which can be established with the help of classical gradient chambers or through photo-chemical release from a caged precursor. We compare the motile properties of amoeboid cells with and without cargo. To analyze the limits of cell-driven micro-transport in more detail, we measure the pulling forces applied to a micron-sized bead by a *Dictyostelium* cell with the help of an optical trap. Furthermore, we demonstrate that not only small objects can be transported in this way, but also larger objects that exceed the size of individual cells by more than an order of magnitude can be moved in a collective effort by aggregates of many cells.

BP 55.7 Thu 17:00 HÜL 386

Cell-Type Specific Mechano-Sensing altered by Blebbistatin — •Galina Kudryasheva and Florian Rehfeldt — III. Physikalisches Institut Friedrich-Hund-Platz 1 37077 Göttingen Germany

Cells sense the stiffness of their surrounding with contractile actomyosin stress fibers through focal adhesions and react to such physical stimuli by altering their bio-chemical pathways. Especially striking is the mechano-guided differentiation of human mesenchymal stem cells (hMSCs) [Engler et al. Cell (2006)]. While the entire differentiation

process can take several days up to weeks, the structure and dynamics of stress fibers can be used as an early morphological marker and theoretically modelled using classical mechanics with an active spring model [Zemel et al. Nat. Phys. (2010)]. We use this approach and the theoretical model to analyze the mechanical cell-matrix interactions of hMSCs and several types of differentiated cells. Using immunofluorescence we visualized stress fibers and analyzed the cytoskeletal morphology [Eltzner et al. PLoS One (2015)] of cells cultured on elastic substrates (E from 1kPa to 130 kPa). Analyzing cell area and cytoskeletal order parameter S we could assign an effective cellular stiffness that shows distinct differences during the differentiation process and for different cell types. Our experiments show that the mechanical susceptibility is cell type specific and dependent on acto-myosin contractility. Interestingly, addition of the non-muscle myosin II (NMM II) inhibitor blebbistatin alters cellular mechano-sensitivity by facilitating cell spreading on soft substrates through relaxing the cellular acto-myosin cortex, but not on stiff substrates.