BP 10: Posters: Tissue Dynamics & Developmental Processes

Time: Monday 17:15–20:00 Location: P3

BP 10.1 Mon 17:15 P3

Entwicklung eines Versuchsaufbaus zur räumlich aufgelösten in-vivo-Messung der viskoelastischen Eigenschaften der humanen Augenlinse — •Stephan Reiss[1], Oliver Stachs[2], Rudolf Guthoff[2] und Heinrich Stolz[1] — [1]Institut für Physik, Universität Rostock, D-18055 Rostock — [2]Medizinische Fakultät, Augenklinik, Universität Rostock, D-18055 Rostock

Die Alterssichtigkeit steht in enger Verbindung mit dem Verlust der Akkommodationsfähigkeit und den viskoelastischen Eigenschaften der Augenlinse. Eine in-vivo-Bestimmung dieser mechanischen Eigenschaften würde ein besseres Verständnis des natürlichen Alterungsprozesses der Linse ermöglichen. Mit den bisher zur Verfügung stehenden Messtechniken ist eine derartige Messung nicht möglich [1]. Wir berichten über ein neues Messverfahren zur ortsaufgelösten in-vivo-Messung der rheologischen Eigenschaften der Augenlinse auf Grundlage der spektroskopischen Auswertung spontaner Brillouin-Streuung mittels eines hochauflösenden "Virtually Imaged Phased Array" [2], welches eine bis zu 20 mal größere Winkeldispersion als ein optisches Gitter besitzt [3], wobei durch die Verwendung eines Multipass-Aufbaus die Auflösung soweit verbessert wurde, dass Messungen an elastisch intensiv streuendem biologischen Gewebe möglich sind. Außerdem präsentieren wir erste ortsaufgelöste Messergebnisse an entnommenen tierischen Augen und Linsen, sowie erste in-vivo-Messungen an einem Kaninchenauge. [1] J. F. Greenlaf, M. Fatemi, and M. Insana, Ann. Rev. Biomed. Eng. 5, 57-78 (2003); [2] M. Shirasaki, Opt. Lett. 21, 366-368 (1996); [3] A. Vega,A. Weiner, and C. Lin, Appl. Opt. 42, No. 20, 4152-4155, (2003)

BP 10.2 Mon 17:15 P3

Novel Magnetic Tweezer with first Applications to Cell and Tissue Stimulation and Rheology — Claus Fütterer[1] and •Rui Caldeira[1,2] — [1]University of Leipzig, Faculty of Physics and Earth Science Institute for Experimental Physics I, Soft Matter Physics Division, Developmental Biophysics, Leipzig, Germany — [2]Universidade de Lisboa, Faculdade de Ciencias, Departamento de Fisica, Lissabon, Portugal

Studying biological samples with laser tweezers releases cosiderable heat perturbing eventually the sample. AFM requires a cantilever to approach the tip to the object in question. Magnetic fields in contrast do not disturb biological samples at all and it is possible to apply forces directly between superparamagnetic micro and nanoparticles applied to the sample in question without the need of immobilization. Those nano and microparticles have been extensively used to measure the visco-elastic properties on the cell membrane plus actin cortex. By switching perpendicular fields we found a new way to assemble those particles to a rich variety of macro-objects and to disassemble them again. 1. We discuss the objects which we found and explain the mechanism of stability. 2. We further discuss applications to study rheology of Hydra Vulgaris tissues in order to find out about the relation of visco-elastic properties and influence of mechanical stimulation onto the symmetry breaking transition during its development. This approach is well suited for high throughput assays in other applications.

BP 10.3 Mon 17:15 P3

Optimal morphogen profiles for combinatorial position determination in the Drosophila embryo — •Tiago Ramalho and Ulrich Gerland — Arnold Sommerfeld Center, Dept. of Physics, Ludwig Maximilians Universität München, Theresienstr. 37 80333 München, Germany

Complex gene transcriptional networks control cell differentiation in the Drosophila embryo, however their behavior depends on the initial concentration profiles of a few morphogens. These morphogens convey positional information by regulating downstream target genes in a combinatorial way. Which combinations of profiles are best suited to accurately determine position anywhere within the embryo? We address this question using established thermodynamic models for combinatorial transcriptional regulation in combination with an optimization procedure based on a quantitative criterion for positional accuracy. We report the optimal profiles for different numbers of input morphogen profiles and discuss our results in the light of the experimentally known profiles for the anteroposterior axis of Drosophila embryos.

BP 10.4 Mon 17:15 P3

Two redundant negative feedback loops in the zebrafish segmentation clock — •Saul Ares[1], Luis G. Morelli[2], Christian Schröter[2], Korneel J. I. Hens[3], Sebastian J. Maerkl[3], Bart Deplancke[3], Andrew C. Oates[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden — [3]École Polytechnique Fédérale de Lausanne, Switzerland

Rhythmic processes are widespread in biology and organisms have evolved different mechanisms to control them. The segmentation clock is a transcriptional oscillator that operates during development and organizes the segmentation of the vertebrate body axis. The hes6 gene has recently been shown to control the clock's period. However, its interaction with other components of the clock, as the cyclic genes her1 and her7, is not known. To study the role of hes6 in the zebrafish segmentation clock, we propose a theory of the gene network controlling the expression of cyclic genes her1 and her7. This gene network is motivated by experimental evidence from genetics, yeast one-hybrid and in vitro assays. The theory comprises two distinct, redundant negative feedback loops. One of these loops relies on a Her7/Hes6 heterodimer, and the other on a Her1 homodimer. Intercellular communication is mediated by two different Hes6 heterodimers and a Her1 protein homodimer. An intriguing finding in our experiments is the rescue of the strong her7 mutant phenotype by further mutating hes6. The theory describes this rescue as an effect of restoring the balance in intercellular communication, which is perturbed in the her7 mutant.

BP 10.5 Mon 17:15 P3

In situ uv/vis spectroscopic imaging of retina cell degeneration — •Julia Hollmach[1], Julia Schweizer[1], Gerald Steiner[1], Richard H. W. Funk[2], Lilla Knels[2], and Edmund Koch[1] — [1]Dresden University of Technology, Faculty of Medicine, Clinical Sensoring and Monitoring, Dresden, Germany — [2]Dresden University of Technology, Faculty of Medicine, Anatomy, Dresden, Germany

In the western world retinal diseases like age-related macular degeneration have become an important cause of visual loss depending on increasing life expectancy and lifestyle habits. Since there is no sufficient treatment, early diagnosis and prevention are the only possibilities to preserve eyesight. The protein cytochrome c (cyt c) is a suitable marker for degeneration processes, because it is involved in the apoptosis pathway. In particular, the local distribution and oxidative state of cyt c are of clinical interest. Cyt c shows two overlapping absorption bands between 500 and 600 nm. Uv/vis spectroscopic imaging was used to characterize the oxidation state and the distribution of the protein in a layer of retina cells. The major challenge was the separation of molecular information from the scattering signal. Extended Multiplicative Scatter Correction in combination with Principal Component Analysis was performed to separate the signals in order to study spectral variances. After multivariate data analysis, cyt c could be identified. The imaging exhibits domains and 'hot spots' of cell degeneration processes. The results demonstrate that spectroscopic imaging in conjunction with sophisticated multivariate methods is a suitable tool to characterize degeneration processes under in situ conditions.

BP 10.6 Mon 17:15 P3

An experimental study of basic correlations of human cardiorespiratory system variables — •Heike Leutheuser[1,3], Thorsten Schaffer[1,3], Christian Jeleazcov[2,3], Christian Weigand[3], and Bernhard Hensel[1] — [1]Max Schaldach-Stiftungsprofessur für Biomedizinische Technik, Universität Erlangen-Nürnberg — [2]Anästhesiologische Klinik, Universitätsklinikum Erlangen — [3]METEAN, Fraunhofer IIS, Erlangen

The human cardiorespiratory system adapts its regulation parameters continuously to variations of physiological demand. The simultaneous and continuous recording of system variables is a necessary basis for a thorough mathematical analysis of the underlying parameters of the cardiorespiratory regulating system. In a experimental trial the most important non-invasively accessible physiological variables have been measured on 10 healthy volunteers during a dedicated exercise protocol. The recordings include ECG, SpO_2, $etCO_2$, respiratory mechanics and continuous non-invasive blood pressure. The test record

includes the Stroop Test as psychological stress test and several physiological exercises, like paced respiration with breathing rates from 4 to 25 breaths per minute, an active orthostatism manoeuvre, a stress test with a bicycle ergometer and the Valsalva manoeuvre. The recorded data are subjected to a variety of algorithms to reveal correlations of the underlying physiological parameters. First results of these investigations are presented. The ultimate goal of the projected work is to derive a cardiorespiratory state parameter that clearly reflects the state of health, respectively fitness, or the progression of disease.

BP 10.7 Mon 17:15 P3

Studying dynamical changes in lung parenchyma by using optical coherence tomography combined with confocal fluorescence microscopy — •Maria Gaertner[1], Peter Cimalla[1], Lilla Knels[2], Sven Meissner[1], Wolfgang M. Kuebler[3], and Edmund Koch[1] — [1]TU Dresden, Faculty of Medicine Carl Gustav Carus, Clinical Sensoring and Monitoring, Dresden, Germany — [2]TU Dresden, Faculty of Medicine Carl Gustav Carus, Department of Anatomy, Dresden, Germany — [3]Institute for Physiology, Charité Berlin, Germany and and Department of Surgery, University of Toronto, Ontario

Realistic lung dynamical investigations on the alveolar microscale are hardly obtainable with conventional techniques such as light microscopy of tissue sections, micro computer tomography or magnetic resonance imaging due to preparation artifacts and damages of the sample or insufficient spatial and temporal resolution, respectively. Optical coherence tomography (OCT) as well as intravital microscopy provide noninvasive, high-resolution (μm), real-time (in 2D) imaging, capable of application to in vivo situations. Furthermore, OCT even extends the morphological information to three dimensions by successive recording of real-time two-dimensional cross-sections within a few seconds. As a new approach, the combination of OCT and confocal fluorescence microscopy shall not only provide 3D data of lung tissue but also localization of elastic fibers embedded in the biological structure through visualization of specifically binding fluorophores. Dynamic studies in an ex vivo mouse model allow for an estimation of overall elasticity as well as investigation of fiber rearrangements.

BP 10.8 Mon 17:15 P3

Finite size corrections to scaling behavior in sorted cell aggregates — •Abigail Klopper[1,2], Gabby Krens[3], Stephan Grill[1,2], and Carl-Philipp Heisenberg[3] — [1]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, D-01187 Dresden, Germany — [2]Max Planck Institute of Molecular Cell Biology and Genetics, Pfotenhauerstraße 108, D-01307 Dresden, Germany — [3]Institute of Science and Technology Austria, Am Campus 1, A-3400 Klosterneuburg, Austria

Cell sorting is a widespread phenomenon pivotal to the early development of multicellular organisms. *In vitro* cell sorting studies have been instrumental in revealing the cellular properties driving this process. However, these studies have as yet been limited to two-dimensional analysis of three-dimensional cell sorting events. Here we describe a method to record the sorting of primary zebrafish ectoderm and mesoderm germ layer progenitor cells in three dimensions over time, and quantitatively analyze their sorting behavior using an order parameter related to heterotypic interface length. We investigate the cell population size dependence of sorted aggregates and find that the germ layer progenitor cells engulfed in the final configuration display a relationship between total interfacial length and system size according to a simple geometrical argument, subject to a finite size effect.

BP 10.9 Mon 17:15 P3

Active fluid: cell-substrate adhesion and cell density cooperatively drive and regulate collective cell migration. — •Kenechukwu David Nnetu, Melanie Knorr, Dan Strehle, Thomas Fuhs, Florian Huber, and Josef Käs — Institut für Experimentelle Physik I, University of Leipzig, Linnéstr 5, 04103, Leipzig, Germany

The collective movement of cells is important for physiological processes such as embryogenesis, cancer metastasis and wound healing. Recent studies showed that marginal and sub-marginal cells drive sheet migrations by generating traction forces transmitted through cell-cell coupling while interfacial tension maintains cohesiveness. By studying the dynamics of sheet migration in 3 dimensions, we show for the first time that collectively, cells spread like a fluid with surface tension playing no role in maintaining dynamic collectivity. We observed further that, reductions in cell height and density led to a loss in cohesion. Moreover, in comparison to single-cell migration, neighboring cells in sheet migration ratify the randomness in single-cell migration into a ballistic motion. These findings together suggest that on 2 dimensional substrates, cell-substrate adhesion drives sheet migration while cell density and intercellular signaling predominantly regulate collectivity as the monolayer spreads like a fluid.

BP 10.10 Mon 17:15 P3

Biochemical and Mechanical Regulation of Growth in Developing Epithelia — •Peer Mumcu[1], Ortrud Wartlick[2], Marcos González-Gaitán[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Department of Biochemistry and Department of Molecular Biology, Geneva University, Switzerland

Developing tissues possess intrinsic growth control mechanisms that determine the final size and shape. The basic principles of growth regulation are still poorly understood. However, there is a lot of evidence that certain morphogens act as growth factors and play a key role in this process. Morphogens are a special class of signaling molecules that are secreted from localized sources, spread throughout the tissue and form graded concentration profiles. We study growth regulation from a theoretical viewpoint using a two-dimensional vertex model that describes the organization of cells by a network of polygons, including the dynamics of morphogen distributions as additional variables. In this theoretical framework, we can study the consequences of specific growth rules according to which cells divide when subject to relative temporal changes of the cellular morphogen levels. We discuss a scenario that is consistent with experimentally observed growth curves obtained in the fruit fly Drosophila. We also discuss the role of mechanical stresses in this system, which can reduce spatial growth inhomogeneities and the rate of cell death.

BP 10.11 Mon 17:15 P3

Vertex model for planar cell polarity: emergence and reorientation of large scale polarity — •Matthias Merkel[1], Douglas B. Staple[1], Reza Farhadifar[1,2], Benoît Aigouy[3], Andreas Sagner[3], Suzanne Eaton[3], and Frank Jülicher[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany — [2]FAS Center for Systems Biology, 7 Divinity Avenue, Cambridge MA 02138, USA — [3]Max-Planck-Institut für molekulare Zellbiologie und Genetik, Pfotenhauerstr. 108, 01307 Dresden, Germany

Epithelia are two-dimensional sheets of cells, which often exhibit large scale patterns of planar cell polarity (PCP) in the tissue plane. Cell polarity is reflected in an anisotropic distribution of a class of proteins, called PCP proteins. This work is motivated by results in the *Drosophila* wing, where during development, large scale reorientation of PCP can be observed. We develop a vertex model in which cells are polygons and the local organization of PCP proteins is described by variables on all bonds. The PCP dynamics is modeled by an attractive interaction within cells and a repulsive interaction across cell borders. Furthermore, we introduce a coupling between PCP and cell shape. We demonstrate how large scale polarity can arise and we study the effect of pure and simple shear on the reorientation of PCP.

[1] B. Aigouy, R. Farhadifar, D.B. Staple, A. Sagner, J.-C. Röper, F. Jülicher, and S. Eaton. *Cell* **142**(5), 773-786 (2010).

BP 10.12 Mon 17:15 P3

Amplitude equation description of vertebrate segmentation — •Adrian Jacobo[1], Damià Gomila[2], Manuel Matías[2], Saul Ares[1], Luis Morelli[1], Andrew Oates[3], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Institute for Cross-Disciplinary Physics and Complex Systems (IFISC), Palma de Mallorca, Spain — [3]Max Planck Institute of Molecular Cell Biology and Genetics, Dresden

The segmentation of the vertebrate body axis is a rhythmic and sequential process controlled by a multicellular clock. This clock has been described either by models of regulatory networks or by simpler descriptions in terms of phase oscillators. While phase oscillators do not consider amplitude effects, gene regulatory networks are too complex to draw any general conclusion about them. Here we address the effects of the amplitude of the oscillations in the segmentation clock. We propose a model based on the Complex Ginzburg-Landau equation. This equation describes an oscillatory medium close to a supercritical Hopf bifurcation, in agreement with accepted gene regulatory network models of the segmentation clock. We find that the amplitude introduces instabilities to the system which are not present in phase descriptions, and were not described by genetic regulatory networks.

These instabilities can lead to distinct regimes, including spatiotemporal chaos. Our theory suggests perturbations to developing embryos that could disrupt the behavior of the segmentation clock.

BP 10.13 Mon 17:15 P3

Mechanics and Morphology of the Dorsal-Ventral compartment boundary in the developing wing of the fly — •Maryam Aliee[1], Constanze Teichman[2], Katharina Landsberg[2], Jens Röper[2], Christian Dahmann[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Max Planck Institute of Molecular Cell Biology and Genetics, 01307 Dresden, Germany

During the development of tissues cells organize into distinct compartments of different cell lineages. The interfaces between these compartments, called compartment boundaries, maintain straight and sharp morphologies. An important model system to study the morphology of compartment boundaries during development is the wing disc of the fruit fly Drosophila where two such boundaries exist: the anterior-posterior boundary and the dorsal-ventral (DV) boundary.

Here, we discuss general physical mechanisms by which compartment boundaries are shaped during the growth phase. Using a vertex model to describe cell mechanics in a growing tissue, we show that the roughness of the compartment boundary can be controlled by increased cell bond tension along the boundary. In addition a locally reduced cell division rate near the boundary leads to an effective interfacial tension and thereby reduced boundary roughness. We compare our results with the shape and mechanics of the DV boundary at different times during the fly wing development. We analyze the role of increased cell bond tension in the morphology of DV boundary and we speculate about the role of localized reduction in cell proliferation.