AKB 75 Nonlinear Phenomena and Pattern Formation

Zeit: Mittwoch 10:15–11:45 Raum: TU H2013

Hauptvortrag

AKB 75.1 Mi 10:15 TU H2013

The Physics of Chemoreception - an Encore — •U. Benjamin Kaupp — Forschungszentrum Jülich, Institut für Biologische Informationsverarbeitung 1, 52425 Jülich

Sperm can navigate in a chemical gradient of attractants released by the egg. The attractant molecules bind to specific receptors on the surface of the sperm flagellum. Activation of receptors initiates a cellular signaling pathway. Within milliseconds, the intracellular messenger cyclic GMP is synthesized. This messenger opens ion channels in the envelope membrane, and Ca ions are flowing into the cell. A sperm cell is exquisitely sensitive: it can respond to the binding of a single attractant molecule. At the same time, sperm respond over a broad range of attractant concentrations (ca. 5 orders of magnitude). This remarkable dynamic range is achieved by two mechanisms. First, the receptor rapidly inactivates; second, the receptor lowers its binding affinity at higher states of occupancy. Both mechanisms enable sperm to escape saturation at high attractant concentrations near the egg. The increase in [Ca] changes the beat pattern of the flagellum. In the unstimulated state, sperm swim in circles. Upon activation by the attractant, sperm undergo a sequence of turns and straight swimming ('turn-and-run'). In a chemical gradient, the behavioural pattern produces epicycloid movements towards the source. The sequence of alternating 'turns' and 'runs' is produced by Ca oscillations in the flagellum that are evoked by the attractant. The Ca oscillations change the properties of motor proteins by unknown mechanisms.

AKB 75.2 Mi 10:45 TU H2013

Role of fluctuations in active hair-bundle mechanics — •Björn Nadrowski[1], Pascal Martin[2], and Frank Jülicher[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Stra"se 38, 01309 Dresden — [2]Laboratoire Physico-Chimie Curie, Unité Mixte de Recherche 168, Institut Curie, 26 rue d'Ulm, F-75248 Paris Cedex 05, France

Hearing relies on active filtering to achieve exquisite sensitivity and sharp frequency selectivity. In a quiet environment, the ears of many vertebrates emit one to several tones. These spontaneous otoacoustic emissions, the most striking manifestation of the inner ear's active process, result from self-sustained mechanical oscillations of aural constituents.

It has been shown that the mechanosensitive hair bundles of vestibular cells from the frog ear have the ability to oscillate spontaneously. This spontaneous oscillation leads to frequency-selective amplification and nonlinearity in the bundles mechanical response.

We discuss the physical principles underlying detection based on critical oscillation as well as specific mechanisms that can lead to oscillations and active behaviors by hair bundles. A simple description of active hair-bundle mechanics is presented. We present the state diagram and show that fluctuations influence the mechanical response functions. We discuss different sources of fluctuations and estimate their influence on the hair-bundle's mechanical properties. Furthermore, the linear and nonlinear response functions calculated numerically can quantitatively account for the observed properties of active hair-bundles.

Nadrowski, Martin, Julicher, PNAS 101, 12195 (2004)

AKB 75.3 Mi 11:00 TU H2013

Symmetry-breaking and axis establishment in Hydra — •Jordi Soriano[1], Sten Rüdiger[2], Pramod Pullarkat[1], Michael Kücken[2], Ernesto Nicola[2], Timo Mai[1] und Albrecht Ott[1] — [1]Experimentalphysik I, Universität Bayreuth. Universitätstraße 30, D-95448 Bayreuth, Deutschland — [2]Theoretische Physik II. Universität Bayreuth. Universitätstraße 30, D-95448 Bayreuth, Deutschland

Hydra may regenerate from a small piece of tissue or from an aggregate of dissociated cells. During the regeneration process the cells first form a hollow sphere made of a cell bi-layer that experiences a series of changes during which the isotropy is broken and a new axis is constituted. We have studied in detail the symmetry-breaking process from an experimental point of view, and focused on the morphogenic and genetic changes that the Hydra-ball experiences during regeneration. We have found that morphogenic oscillations are essential for symmetry-breaking, and that they may trigger the key genetic mechanisms responsible for the constitution and maintenance of the axis and the subsequent development. We also propose a new reaction-diffusion model to describe the symmetry-breaking process.

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Robustness and Precision in Morphogen Gradient Formation — •Tobias Bollenbach[1], Karsten Kruse[1], Periklis Pantazis[2], Marcos González-Gaitán[2], and Frank Jülicher[1] — [1]MPI for Physics of Complex Systems, Nöthnitzerstr. 38, 01187 Dresden — [2]MPI for Molecular Cell Biology and Genetics, Pfotenhauerstr. 108, 01307 Dresden

Morphogens are signaling molecules that play a key role in animal development. They spread from a restricted source into an adjacent target tissue forming a concentration gradient. The fate of cells in the target tissue is determined by the local concentration of such morphogens. Morphogen transport through the tissue has been studied in experiments which lead to the suggestion of several transport mechanisms. While diffusion in the extracellular space contributes to transport, recent experiments on the morphogen Dpp in the fruit fly Drosophila provide evidence for the importance of a cellular transport mechanism that was termed "planar transcytosis". In this mechanism, morphogens are transported through cells by repeated rounds of internalization and externalization. Starting from a microscopic description of these processes, we derive nonlinear transport equations which describe the interplay of transcytosis and passive diffusion. We find that transcytosis leads to an increased robustness of the created gradients with respect to morphogen over-expression. This robustness has been observed in experiments. We finally relate our description to recent experiments.

AKB 75.5 Mi 11:30 TU H2013

Mechanical Properties of self-assembling biomolecular tubes — •Iwan A.T. Schaap[1], Pedro J. de Pablo[1], Catherine Tardin[1], Andrew Turberfield[2], Richard Berry[2], Cees G. de Kruif[3], Joanke Graveland[3], Bernd Hoffmann[4], Frederick C. MacKintosh[1], and Christoph F. Schmidt[1] — [1]Dept. Physics, Vrije Universiteit, Amsterdam, NL — [2]Dept. Physics, Oxford University, Oxford, UK — [3]NIZO Food Research, Ede, NL — [4]Forschungsztr. Julich, Julich, D

Biomacromolecules often have the capability to self-assemble into either functional and well regulated or pathogenic unregulated structures. Examples for the former are cytoskeletal filaments such as microtubules, 25 nm hollow tubes made of tubulin protein. The latter occurs in many neurodegenerative diseases (amyloid formation). Molecular self-assembly can also be put to technical use, for example by engineering self-assembling DNA building blocks. We have employed an atomic force microscope (AFM) operated at well-controlled low forces to image under physiological conditions various tube-like structures at nm resolution, including microtubules with and without accessory proteins, protein amyloid tubes and DNA tubes. To measure mechanical properties, we have indented individual tubes locally with the AFM tip. The deformation is elastic for the few nm of indentation. By indenting with higher forces, we can exceeded elastic limits and produce local defects.