BP 42: Neurosciences

Time: Wednesday 15:00–17:30 Location: ZEU 250

Invited Talk BP 42.1 Wed 15:00 ZEU 250

Linking AMPA receptor nanoscale organization and function at excitatory synapses — •Daniel Choquet — Interdisciplinary Institute for Neuroscience, CNRS, Université de Bordeaux, Bordeaux, France,

The spatio-temporal organization of neurotransmitter receptors in the postsynaptic membrane is a fundamental determinant of synaptic transmission and thus information processing by the brain. Using a combination of high resolution single molecule imaging techniques and video-microscopy, we had previously established that AMPARs are not stable in the synapse as thought initially, but undergo continuous entry and exit to and from the post-synaptic density through lateral diffusion. Using three independent super-resolution imaging methods, on both genetically tagged and endogenous receptors, we demonstrated that, in live hippocampal neurons, AMPAR are highly concentrated inside synapses into a few clusters of around seventy nanometers. AMPAR are stabilized reversibly in these domains and diffuse freely outside them. These results open the new possibility that glutamatergic synaptic transmission is controlled by the regulation at the nanometer scale of the position and composition of these highly concentrated nanodomains. This finding provides a functional support to our hypothesis that fast AMPAR surface diffusion can tune short term plasticity by allowing fast replacement of desensitized AMPAR by naïve ones during high frequency stimulation.

BP 42.2 Wed 15:30 ZEU 250

Hippocample learning with memristive devices: device requirements for the use in recurrent networks — •Nick Diederich[1,2], Thorsten Bartsch[2], Martin Ziegler[1], and Hermann Kohlstedt[1] — [1]Technische Fakultät, Christian-Albrechts-Universität zu Kiel — [2]Neurologie, Universitätsklinik Schleswig-Holstein

Memristive devices are considered as promising candidates for hardware based synapses since they fulfill important biological plasticity rules such as long-term potentiation and long-term depression. Furthermore, their low energy consumption, scalability, and rather simple device structure are especially interesting for artificial neural networks. In this talk, the opportunities of memristive devices for recurrent neural-networks are presented. Those networks are in particular important structures in mammal brains. In detail, a memristive network-model of the hippocampale loop is presented which allows the realization of physiological behavior of learning. The unique behaviors and desired device characteristics of memristive devices for those network structures will be discussed.

Financial support by the German Research Foundation through FOR 2093 is gratefully acknowledged.

BP 42.3 Wed 15:45 ZEU 250

Protocol for fluctuation analysis of ion channel currents in nonstationary conditions: application to Ca^{2+} channels — •Christian Scheppach[1,2] and Hugh P.C. Robinson[2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg i. Br., Germany — [2]Department of Physiology, Development and Neuroscience, University of Cambridge, U.K.

Fluctuation analysis is a method which allows measurement of the single channel current of ion channels even when it is too small to be resolved directly with the patch clamp technique. The method in its original form depends on stationary conditions, such that meaningful ensemble-averaging over several successive current traces can be performed. However, experimentally this is sometimes not possible, for example when the ion channel current runs down rapidly. We therefore developed a novel fluctuation analysis protocol which extracts information from individual current traces. It is based on voltage ramp stimulation, mean current fitting of individual current responses and band-pass filtering. We apply the method to Ca^{2+} channels in pyramidal neurons of layer 5 of rat neocortex, arriving at a single-channel current of 0.07 pA (membrane potential: −20 mV; external Ca^{2+} concentration: 2 mM). We validate the accuracy of the method by analysing simulated data and compare it with another established method of dealing with ion channel rundown.

Reference: C. Scheppach & H.P.C. Robinson (arXiv, under review).

BP 42.4 Wed 16:00 ZEU 250

A circuit to mimic a bio-inspired two-alternatives decision-making experiment based on elementary motion detection — •Tom Birkoben, Mirko Hansen, Marina Ignatov, Martin Ziegler, and Hermann Kohlstedt — Nanoelektronik, Technische Fakultät, Christian Albrechts Universität zu Kiel, Germany

Decision-making belongs to one of the most important principles in the nervous system of living species. A decision is based on the temporally available sensory input data and previous experiences made in similar situations, i.e. related to memory and reward. In-depth studies utilizing two-alternatives saccadic eye movement tasks led to a profound understanding of neuronal information processing. Three fundamental processing stages are needed to perform this kind of tasks successfully: a neuronal representation of the sensory signal, the integration of the stimuli and the comparison of the accumulated information to a threshold for a final decision. We present an analogue electronic decision-making circuit. Our concept study includes an LED-matrix as the task screen, an array of photo diodes, a Hassenstein-Reichardt Detector based motion detection and finally a signal integration circuit based on an inhibitory coupling scheme. The biologically well motivated effects of previous experiences (memory and reward) for decision making might be effectively implemented into the circuit by memristive devices, which will be discussed in the framework of I-V characteristics and the circuit layout.

Financial Support by the German Research Foundation through FOR 2093 is gratefully acknowledged.

15 min break

BP 42.5 Wed 16:30 ZEU 250

The temporal dimension of information coding in the brain, studied via neuroimaging in an insect model. — Marco Paoli[1], Angela Albi[1], Renzo Antolini[1,2], and •Albrecht Haase[1,2] — [1]Center for Mind/Brain Sciences, University of Trento, Italy — [2]Department of Physics, University of Trento, Italy

We apply fast two-photon calcium imaging to study information coding in the brain of honeybees. Recording the responses of the first local neuronal network along the olfactory pathway, the antennal lobe, we investigate whether information about the odour stimulus is encoded in temporal features of the neuronal activation. Besides the spatial distribution of activation, we identified odour-specific oscillatory features modulating the slow activation curves. Furthermore, we found that the activation onset varies for different stimuli and different network nodes. By predicting test odours only from the order of network node activation, we proof that these response latencies form an odour-specific code across individuals.

BP 42.6 Wed 16:45 ZEU 250

On collision of action potentials — •Christian Fillafer, Anne Paeger, and Matthias F. Schneider — Technische Universität Dortmund, Medizinische und Biologische Physik, Dortmund, Germany

It is a common incident in nature, that two waves or pulses run into each other head-on. The outcome of such an event is of special interest, because it allows conclusions about the underlying physical nature of the pulses. The present experimental study dealt with the head-on meeting of two action potentials (AP) in a single excitable plant cell (Chara braunii internode). The membrane potential was monitored at the two extremal regions of an excitable cell. In control experiments, an AP was excited electrically at either end of the cell cylinder. Subsequently, stimuli were applied simultaneously at both ends of the cell in order to generate two APs that met each other head-on. When two action potentials propagated into each other, the pulses did not penetrate but annihilated (N=14 experiments in n=4 cells). It was difficult to judge whether annihilation was complete or partial. A small data set indicated that both outcomes are possible. APs in excitable plant cells did not penetrate upon meeting head-on. In the classical electrical model, this behavior is attributed to relaxation of ion channel proteins. From an acoustic point of view, annihilation is a result of nonlinear material properties of the excitable medium. The present results indicate that APs in excitable animal and plant cells are similar nonlinear phenomena. Intriguingly, other excitation waves in biology (intracellular waves, cortical spreading depression, etc.) also annihi-

late upon collision and thus may be fundamentally related to action potentials.

BP 42.7 Wed 17:00 ZEU 250

Patch Clamping of T cells and Neurons on Nanowire Substrates — •Jann Harberts[1], Aune Koitmäe[1], Gabriele Loers[2], Carsten Ronning[3], Heiner Linke[4], and Robert H. Blick[1,5] — [1]Institute of Nanostructures and Solid State Physics (INF), Hamburg — [2]Center for Molecular Neurobiology Hamburg (ZMNH) — [3]Institute for Solid State Physics, University of Jena — [4]Solid State Physics, Lund University, Sweden — [5]Center for Hybrid Nanostructures (CHyN), Hamburg

Nano- and micro-structured substrates achieved an increasing amount of interest in cell biology during the recent years. Chemical and physical properties of culturing substrates have a significant influence on adhesion and viability of overgrowing cells. For instance, substrates with vertically aligned nanowires (NWs) can control the outgrowth of cells depending on diameter, length and density.

Typically, such experimental studies are analyzed with staining techniques in fluorescent microscopes. For quantitative measurements of cell characteristics, such as gating properties of ion channels, a more precise method—the patch clamp technique—is required. This technique facilitates the exact measurement of currents and voltages at the cell membrane. A potential disadvantge is the mechanical pressure on the cell during the measurement procedure, which could damage the cell, especially on NW substrates. However, conventional patch clamp setups are not designed for patch clamping on opaque substrates. We present a modified setup which meets this requirement and show successful measurements of T cells and neurons settled on NW substrates.

BP 42.8 Wed 17:15 ZEU 250

On the Mechanical Component of an Action Potential — •Matan Mussel, Christian Fillafer, and Matthias F. Schneider — Technische Universität Dortmund, Dortmund, Germany

Action potentials (AP) in neurons are accompanied by a bi-phasic surface displacement, which is composed of swelling during depolarization and contraction during repolarization. This mechanical pulse (∼1–10 nm) has not received a satisfactory explanation up to date. Herein, we present results on mechanical changes during AP propagation in excitable plant cells (internodes of Chara Braunii). In a native Chara cell, the plasma membrane is tightly pressed against the cell wall by turgor pressure (∼6 bar). In order to directly study deformations of the cell surface, turgor pressure was reduced by osmosis until the plasma membrane detached from the cell wall. Upon excitation of an AP, the surface displaced by ∼1–10 um. This mechanical deflection (i) propagated with the same velocity as the electrical pulse (∼10 mm/s), (ii) was reversible and (iii) in most cases of biphasic nature. We propose a mechanical model that describes these shape transformations as an interplay between the surface forces and the pressure difference across the surface. Our model captures the essence of the cell shape dynamics and makes testable predictions about the underlying mechanism.