BP 8: Charge Transfer

Time: Monday 18:00–19:30 Location: H44

BP 8.1 Mon 18:00 H44

Three-dimensional conductance mapping on living cells with scanning ion conductance microscopy — •Matthias Böcker[1,2], Joachim Wegener[3], and Tilman Schäffer[1,2] — [1]Center for Nanotechnology (CeNTech), Heisenbergstr. 11, 48149 Münster — [2]Physikalisches Institut, Wilhelm-Klemm-Str. 10, 48149 Münster — [3]Institut für Biochemie, Wilhelm-Klemm-Str. 2, 48149 Münster

A scanning ion conductance microscope (SICM) is based on an electrolyte-filled, tapered micropipette that acts as nanoscale current probe while being scanned over a sample surface. We used SICM to study the ion permeability of tissue-like cell layers with lateral resolution. For MDCK-II cells, we measured a larger ion conductance along the cell periphery in areas of cell-cell contacts, compared to that along the cell bodies. This suggests that ions mainly pass through the paracellular cleft between adjacent cells but not through the cellular plasma membrane.

In order to further refine these measurements, we implemented a novel three-dimensional imaging mode. In this mode, the micropipette is scanned in all three spatial dimensions over the sample surface while recording the ion conductance. The sample surface topography is tracked by using a complementary shear-force distance control with an optical readout. This allows us to create maps of ion conductance not only in a plane, but in a volume directly above the sample surface, revealing refined aspects of conductive sample properties.

BP 8.2 Mon 18:15 H44

Chemically driven electron tunnelling pumps — •Igor Goychuk — Universität Augsburg, Germany

The simplest mechanism for molecular electron pumps is discussed [1] which is based on nonadiabatic electron tunnelling and nonequilibrium conformational fluctuations [2,3]. Such fluctuations can be induced, e.g. by random binding of negatively charged ATP molecules to the electron-transferring molecular complex, their subsequent hydrolysis and the products dissociation. The pumping rate can be controlled by the ATP concentration in solution. Depending on the model parameters there may exist a critical ATP concentration for the pump to function. For realistically chosen parameters, the mechanism is shown to be robust and highly efficient. Such a mechanism is tentatively realised in nitrogenase protein complexes [4].

[1] I. Goychuk, Molecular Simulation **9**, 717 (2006) (Special Issue on Electron Transfer).
[2] I. A. Goychuk, E. G. Petrov, V. May, Phys. Rev. E **56**, 1421 (1997).
[3] I. Goychuk, P. Hänggi, Adv. Phys. **54**, 525 (2005).
[4] I. V. Kurnikov, A. K. Charnley, D. N. Beratan, J. Phys. Chem. B, **105**, 5359 (2001).

BP 8.3 Mon 18:30 H44

Electrostatic screening and energy barriers for ion translocation across low-dielectric membranes — •Andrey Cherstvy — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzerstrasse 38, D-01187 Dresden, Germany

We present exact solutions of the linear Poisson-Boltzmann equation for several problems relevant for ion translocation across low-dielectric membranes [1]. Our results are obtained for a finite Debye screening length, and they generalize the classical results for pure Coulombic electrostatics [2]. We calculate the electrostatic self-energy of an ion in the middle of a low-dielectric slab, its energy inside a cylindrical high-dielectric pore, and its energy inside a high-dielectric spherical jacket. We consider also the influence of negative charges distributed on the walls of the cylindrical pore. We show that ion self-energy barriers are considerably reduced due to screening of electrolyte. We compare our results with some numerical results for screened electrostatic interactions in ion channels and wide biological pores [3].

[1] A. G. Cherstvy, J. Phys. Chem. B, 110, 14503 (2006). [2] A. V. Parsegian, Nature (London), 221, 844 (1969). [3] P. C. Jordan et al., Biophys. J. 55, 1041 (1989).

BP 8.4 Mon 18:45 H44

Localization of electronic states of proteins probed by resonant photoemission — •Denis Vyalikh[1], Volodymyr Maslyuk[2], Andreas Kade[1], Alexander Kirchner[3], Anja Blüher[3], Ingrid Mertig[2], Michael Mertig[3], and Serguei Molodtsov[1] — [1]Institut für Festkörperphysik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Martin-Luther-Universität Halle-Wittenberg, Fachbereich Physik, D-06099 Halle, Germany — [3]Max-Bergmann-Zentrum für Biomaterialien, Technische Universität Dresden, D-01062 Dresden, Germany

The electronic structure of the biological system - regular two-dimensional bacterial surface protein layer (S layer) of Bacillus sphaericus NCTC 9602 - was investigated by resonant photoemission (PE) spectroscopy at the C 1s, N 1s and O 1s absorption edges. Resonant PE spectra taken in the vicinity of the C 1s absorption threshold exhibit an enhancement of the valence-band emission, indicating rather localized character of the lowest laying unoccupied orbitals. We have established kinetic energy shifts of the O- and N- KVV Auger lines across excitations of primarily electrons into the corresponding π^* resonances that can help to shed light on the electron transport properties in the extremely large biomolecules.

BP 8.5 Mon 19:00 H44

Hopping transport through nanowires: a unified approach to DNA charge transfer — Tobias Cramer, Sebastian Krapf, and •Thorsten Koslowski — Institut für Physikalische Chemie, Universität Freiburg, Albertsrasse 23a, D-79104 Freiburg im Breisgau

We address the problem of DNA charge transfer from a theoretical and numerical perspective. The electronic structure is described atomistically and chemically specific by an extended Su-Schrieffer-Heeger Hamiltonian that can be solved self-consistently [1]. The emerging potential energy surface exhibits the characteristics of small polaron formation. It can be analyzed to obtain the parameters relevant to Marcus' theory of thermally excited charge transfer. The findings are not only compatible with DNA photofragmentation experiments [2], but also provide an accurate description of charge transfer through bio-nano contacts. The resulting rate equations lead to a maximum current of 5 nA per A-DNA double strand upon the application of a potential of $\pm$ 2 V, a value comparable to recent experimental findings. In addition, we reproduce the overall shape of the experimental I-V curves and their pronounced dependence upon the DNA sequence [3].

[1] M. Rateitzak, and T. Koslowski, Chem. Phys. Lett. 377, 455 (2003)
[2] T. Cramer, S. Krapf, and T. Koslowski, J. Phys. Chem. B, 108, 11812 (2004); T. Cramer, A. Volta, A. Blumen, and T. Koslowski, J. Phys. Chem. B 108, 16586 (2004)
[3] T. Cramer, S. Krapf, and T. Koslowski, submitted for publication

BP 8.6 Mon 19:15 H44

Near-field optical imaging of a free-standing biological membrane under physiological conditions — •Nicole Neuberth[1], Michael Hermann[2], Joerg Wissler[1], Daniela Diessel[1], Dietmar Gradl[2], and Andreas Naber[1] — [1]Institut für Angewandte Physik, Universitaet Karlsruhe (TH) — [2]Zoologisches Institut II, Universitaet Karlsruhe (TH)

Nuclear pore complexes (NPCs) are supramolecular assemblies embedded in the nuclear envelope (NE) of a cell. They constitute a major gateway for the transport of molecules in and out of the nucleus. Though considerable insight has been gained into the signal-mediated translocation, it is still under debate in which way the structural properties of an NPC are related to its function as a "biological transport machine". We have recently demonstrated that SNOM provides a new possibility for an investigation of unfixed biological membranes [1]. For the intended transport studies, we improved the quality of our SNOM probe such that single molecule measurements with 30-nm-resolution are obtained routinely [2]. We developed a template based on cylindrical cavities in a photo-resist, and free-standing membrane patches are formed over the cavities by spreading the NE on the surface. We will present first near-field optical results of an unsupported nuclear membrane.

[1] C. Hoeppener et al., Biophys. J. 88, 3681 (2005).
[2] D. Molenda et al., Optics Exp. 13, 10688 (2005).