AKB 15 Biopolymers II

Time: Tuesday 16:30–18:30 Room: ZEU 260

AKB 15.1 Tue 16:30 ZEU 260

Apparent Persistence Length Renormalization of Bent DNA — •Helmut Schiessel[1], Igor M. Kulic[2], Herve Mohrbach[3], and Rochish Thaokar[4] — [1]Instituut-Lorentz, Universiteit Leiden, The Netherlands — [2]Dept. of Physics and Astronomy, University of Pennsylvania, Philadelphia, USA — [3]LPMC, Metz University, France — [4]Dept. of Chemical Engineering, IIT, Bombay, India

We derive the single molecule equation of state (force-extension relation) for DNA molecules bearing sliding loops and deflection defects. Analytical results are obtained in the large force limit by employing an analogy with instantons in quantum mechanical tunneling problems. The results reveal a remarkable feature of sliding loops - an apparent strong reduction of the persistence length. We generalize these results to several other experimentally interesting situations ranging from rigid DNA-protein loops to the problem of anchoring deflections in AFM stretching of semiflexible polymers. Expressions relating the force-extension measurements to the underlying loop/boundary deflection geometry are provided and applied to the case of the GalR-loop complex.

AKB 15.2 Tue 16:45 ZEU 260

Hydrodynamic interactions for stiff polymers — •Jens Glaser[1], Oskar Hallatschek[2], and Klaus Kroy[1] — [1]Institut für theoretische Physik, Universität Leipzig, PF 100 920, 04009 Leipzig — [2]Harvard University, Lyman Laboratory, Cambridge MA 02138

The minimal model for the statics and dynamics of stiff polymers such as the polymers of the cytoskeleton is the wormlike chain. For quantitative predictions of wormlike chain dynamics non-local hydrodynamic interactions (HI) have to be taken into account. The importance of a correct treatment of HI is discussed for the short- and long-time limits of the dynamic structure factor. The results are compared with those of recent dynamic light scattering experiments, e.g. for actin. For extracting consistent and reliable values of the model parameters (persistence length and the backbone thickness) inclusion of HI on the Rotne-Prager level is found to be necessary and sufficient. As another example, a stiff polymer under the influence of a constant external force field, e.g. gravity, is discussed. HI induces a spontaneous symmetry breaking. The corresponding conformational dynamics is analyzed analytically.

AKB 15.3 Tue 17:00 ZEU 260

Dynamics of single semiflexible polymers under force — •Benedikt Obermayer[1], Oskar Hallatschek[2], Klaus Kroy[1], and Erwin Frey[3] — [1]Institut für Theoretische Physik, Universität Leipzig, Augustusplatz 10-11, 04109 Leipzig — [2]Lyman Laboratory of Physics 426, Harvard University, Cambridge, MA 02138 — [3]Arnold Sommerfeld Center for Theoretical Physics, LMU München, Theresienstr. 37, 80333 München

The wormlike chain model gives an accurate theoretical description for many important semiflexible biopolymers. While their static equilibrium properties are well known, the dynamics under external forces is not yet completely understood. We have analyzed the response to forces acting in longitudinal and transverse direction for single chains under thermal conditions in the weakly-bending limit. Since the longitudinal dynamics is closely related to backbone tension, a unified description of its propagation and relaxation behavior provides both a rigorous formalism as well as an intuitive understanding of the dominant relaxation mechanisms; hence we can systematically substantiate and restrict previous heuristic approaches. We present our results in terms of asymptotic scaling laws and by means of crossover solutions computed numerically, and we point out experimental implications.

AKB 15.4 Tue 17:15 ZEU 260

Vibrational imaging of single type I collagen fibrils by multiplex CARS microscopy — •Adam Muschielok, Marina Kovaleva, Alexander Kovalev, and Andreas Volkmer — 3rd Institute of Physics, University of Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart

Collagen, one of the most abundant proteins in the extracellular matrix of animals, is important for the stability of tissues. Furthermore, because of its ability to self-assemble into fibrils, it is used as a model system for the formation of biopolymer structures. We have employed coherent anti-Stokes Raman scattering (CARS) microscopy in order to study the vibrational properties of individual in-vitro grown type I collagen fibrils. CARS microscopy allows the non-invasive imaging of collagen fibrils with high sensitivity, with three-dimensional sectioning capability, and with high spatial resolution. Beyond imaging, a multiplex CARS scheme was employed for the fast acquisition of CARS spectra in the region of the C-H stretching vibration. A detailed spectral analysis will be presented, which yields a representation of characteristic Raman line shape parameters in space, directly revealing the chemical and physical properties of a single collagen fibril in solution.

AKB 15.5 Tue 17:30 ZEU 260

Diffusion and intramolecular dynamics of double-stranded DNA in solution — •Eugene P. Petrov[1], Thomas Ohrt[1], Roland G. Winkler[2], and Petra Schwille[1] — [1]Institute of Biophysics / BIOTEC, TU Dresden, Tatzberg 47-51, 01307 Dresden — [2]IFF, Forschungszentrum Jülich, 52425 Jülich

We present results of an experimental investigation of diffusional motion and intramolecular dynamics of double-stranded DNA molecules in solution at the room temperature. Dynamics of single-end fluorescently labeled lambda-DNA fragments with lengths covering the range of 10^2 to 10^4 base pairs were studied by means of fluorescence correlation spectroscopy (FCS). Mean-square displacement of the fluorescently labeled end obtained from FCS data scales at short times as $t^{2/3}$, thus indicating the Zimm-type dynamics of the DNA polymer in solution. The experimental data are in a good agreement with the predictions of the theory of semiflexible polymers [1], which allows to extract diffusion coefficients and intramolecular relaxation times of DNA in solution from FCS measurements.

[1] L. Harnau, R.G. Winkler, P. Reineker, J. Chem. Phys. **104**, 6355 (1996).

AKB 15.6 Tue 17:45 ZEU 260

Characterizing Formin: A Step-By-Step Approach — •Brian Gentry — Institute for Soft Matter Physics, Uni-Leipzig, Linnéstr. 5 04103 Leipzig

The actin cytoskeleton in Eukaryotic cells is a complex system capable of dynamic reorganization during motility processes. Many actin-binding proteins are involved in the reorganization, including motors, cappers and molecules which nucleate and branch filaments. Formin is an end-binding molecular engine which is capable of nucleating and driving the polymerization of actin polymers in vivo. It is involved in the formation of long, unbranched massive actin fibers, such as those found in filipodia. We are currently studying formin and its ability to drive polymerization in vitro using laser tweezers. Using this state-of-the-art method we are investigating the force produced as well as the stepsize of the motor and hope to gain insight into the underlying dynamics of its operation. This method will allow us to directly measure polymerization forces in a controlled manner.

AKB 15.7 Tue 18:00 ZEU 260

Thermophoresis is Entropophoresis — •Stefan Duhr and Dieter Braun — Noether Group on Dissipative Microsystems, Applied Physics, Ludwig Maximilians Universität München, Amalienstr. 54, 80799 München, Germany

Molecules move along temperature gradients, a phenomenon known from experiments for 150. The effect is called thermophoresis, Soret-effect or thermal diffusion. Here we present experiments which back a unifying theoretical explanation. Measurements span a wide range of molecule types and sizes, possible by the use of a novel fluorescence technique which measures thermophoresis in 10 picoliter microfluidics. Optically imposed temperature patterns are shown to manipulate molecules in solution on the micron scale. Our experiments demonstrate that thermophoresis is driven by the entropy of solvation. In water, two solvation entropies counteract. Entropy of ionic shielding leads to thermophobic depletion. Entropy of hydration results in thermophilic accumulation at low overall temperatures. The theory predicts thermophoresis of polystyrene beads and DNA with 10 % accuracy without free parameters. It allows the determination of the effective charge and hydration entropy over a wide molecule size range not measurable with electrophoresis. With this theoretical foundation, thermophoresis can be used for all-optical quantitative biomolecule analysis.

AKB 15.8 Tue 18:15 ZEU 260

Microtubule Dynamic Instability analyzed in 3D over time with Selective Plane Illumination Microscopy — •Philipp Keller, Francesco Pampaloni, Klaus Greger, and Ernst Stelzer — EMBL Heidelberg, Cell Biology and Biophysics Unit, Meyerhofstraße 1, 69117 Heidelberg

Microtubules (MTs) are highly dynamic cytoskeletal filaments that continuously undergo stages of growth and shrinkage (dynamic instability). MTs radiate from a MT organizing center, forming starshaped MTs asters. In our studies of MT asters, we transfer the two-dimensional experiments of MT dynamic instability performed between two closely-spaced glass flats, to a three-dimensional environment and use the SPIM for imaging. Experiments are performed in vitro using Xenopus laevis egg extracts, providing us with a physiological yet biochemically easily modifiable system. Three-dimensional sample preparation ensures a minimal area of artificial surfaces and an unconstrained development of the asters in three dimensions. Apart from addressing the fundamental questions of MT dynamics, this approach allows us to phrase questions that specifically focus on three-dimensional aspects of MT structural dynamics. In our SPIM data sets, the evaluation of three-dimensional MT length distributions over time takes basically all of the asters' MTs into account. This provides us with a very good statistical basis to test and improve theoretical models of dynamic instability.