

SCIENTIFIC AND METHOD MODULES

Module name	Nanomanipulations
Number	2009-M01
Aims	Building with molecules and nano-objects requires the manipulation of these entities on a nanoscale. Such manipulations have to be local and therefore require the use of localized force fields that act on single particles, cells or even single molecules. The lecture series gives an introduction into modern techniques and the physical principles behind.
Basics	Molecular and intermolecular forces, electrostatic forces, magnetic forces, optical forces, mechanical forces, thermophoretic forces, ultrasound, micro- and nanostructures
Contents	1. Electromagnetic forces: electric fields and dielectric materials, electrophoresis for molecules, proteins, and cells, magnetic forces. 2. Optical forces: gradient, scattering, and optical surface forces, Maxwell surface tensor, momentum transfer, transferring angular momentum, holographic tweezers, Mie- vs. Raleigh-regime. 3. Scanning force approaches: Van der Waals forces, inter- and intra-molecular interactions, detection with quadrant diodes. 4. Thermophoretic forces, thermo-viscous pumping, opto-thermal molecule trapping 5. Soft lithography
Methods	Optical traps (optical tweezers, optical stretcher, optical cell guidance, optical spanners and rotators, optical sorting and deposition, laser dissection), magnetical tweezers, scanning force microscopy and spectroscopy, electrokinetic trapping, thermophoretic forces.
Type	Two-day block course/ yearly recurrence with modification
Date (month/year)	28./29. Mai 2009
Time	9.00 – 18.00
Work load	15 hours presence/ 45 hours self-study
Examination	Oral
Credit points	2
Responsible scientists	Cichos
International guest lecturers	Prof. Alois Würger (Bordeaux I), Prof. Adam Cohen (Harvard)
Industrial partners	None
Recommendations for literature, e-learning	"Single Molecule Techniques: A Laboratory Manual", Paul R. Selvin, Taekjip Ha, <u>Cold Spring Harbor Laboratory Press</u>, Cold Spring Harbor, New York, 2008. "Intermolecular and Surface Forces", J. N. Israelachvili, Academic Press, London, 1992. Rief, M., M. Gautel, et al. (1997). "Reversible unfolding of individual titin immunoglobulin domains by AFM." <u>Science</u> 276(5315): 1109-12. Dietz, H., F. Berkemeier, et al. (2006). "Anisotropic deformation response of single protein molecules." <u>Proc Natl Acad Sci U S A</u> 103(34): 12724-8. Junker, J. P., F. Ziegler, et al. (2009). "Ligand-dependent equilibrium fluctuations of single calmodulin molecules." <u>Science</u> 323(5914): 633-7. Borgia, A., P. M. Williams, et al. (2008). "Single-molecule studies of protein folding." <u>Annu Rev Biochem</u> 77: 101-25. John Anderson, <u>Ann. Rev. Fluid Mech.</u> 21, 61 (1989).

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M.L. Bennink et al., "Unfolding individual nucleosomes by stretching single chromatin fibers with optical tweezers", Nat Struct Biol. 8, 606 (2001).

A. E. Cohen, "Control of nanoparticles with arbitrary two-dimensional force fields", Phys. Rev. Lett. 94, 118102, (2005).

A. E. Cohen and W. E. Moerner, "Suppressing Brownian motion of individual biomolecules in solution", PNAS, 103, 4362-4365, (2006).

A. E. Cohen, W. E. Moerner, "Internal mechanical response of a polymer in solution", Phys. Rev. Lett. 98, 116001, (2007).

M. Salomo et al., "Optical tweezers to study single protein immunoglobulin interactions at varying conditions", Eur. Biophys. J. 37(6), 927 (2008).

E. Evans, "Probing the relation between force-lifetime-and chemistry in single molecular bond", Ann. Rev. of Biophys. Biomol. Struc. 30, 105 (2001).

A. Ashkin, "Optical trapping and manipulation of neutral particles using lasers", PNAS USA 94, 4853 (1997).

C. Gutsche, U. F. Keyser, K. Kegler, F. Kremer, "Forces between single pairs of charged colloids in aqueous salt solutions", Phys. Rev. E 76, 031403 (2007).

A. Jusufi, C. N. Likos, M. Ballauff, "Counterion distributions and effective interactions of spherical polyelectrolyte brushes", Coll. Polym. Sci. 282, 910 (2004).

G. Dominguez-Espinosa, A. Synytska, A. Drechsler, C. Gutsche, K. Kegler, P. Uhlmann, M. Stamm, F. Kremer, "Optical tweezers to measure the interaction between poly(acrylic acid) brushes", Polymer 49, 4802 (2008).

F. M. Weinert, J. A. Kraus, T. Franosch, and D. Braun, "Microscale Fluid Flow Induced by Thermoviscous Expansion Along a Traveling Wave", Phys. Rev. Lett. 100, 164501 (2008).

F. M. Weinert and D. Braun, "Optically driven fluid flow along arbitrary microscale patterns using thermoviscous expansion", J. Appl. Phys. 104, 104701 (2008)

F. M. Weinert, M. Wühr and D. Braun, "Light driven microflow in ice", Appl. Phys. Lett. 94, 113901 (2009)

Thursday 28.5.2009: SR 115 in the Chemistry Building

time	lecturer	title
09:00-09:15	Frank Cichos	Introduction
09:15-10:00	Frank Cichos (Leipzig)	Optical Single Molecule Detection for Nanomanipulations
10:15-11:00	Alois Würger (Université Bordeaux I)	Phoretic motion of colloidal particles
11:15-12:00	Franz Weinert (LMU)	Optical Pumping and Thermophoretic Trapping
lunch		
13:30-14:15	Adam Cohen (Harvard)	Electrokinetic Single Molecule Trapping
14:30-15:15	Adam Cohen (Harvard)	Electrokinetic Single Molecule Trapping
15:30-16:15	Mahdy Elmahdy (Leipzig)	Forces of interaction between polymer-grafted colloids as measured by Optical Tweezers

Friday 29.5.2009: SR 101 in the Chemistry Building

time	lecturer	title
09:00-09:45	Josef Käs (Leipzig)	Optical Micro- and Nanomanipulations: Going beyond Optical Tweezers
10:00-10:45	Ralf Seidel (Dresden)	Magnetic tweezers: A tool to study polymer mechanics and single enzymes
11:00-11:45	Morten Bertz (TUM)	Single-molecule Force Spectroscopy of Proteins and Protein Complexes
lunch		
13:30-14:15	Morten Bertz (TUM)	Single-molecule Force Spectroscopy of Proteins and Protein Complexes
14:30-15:15	Florian Rehfeldt (Göttingen)	Measuring the Mechanical Properties of Cells and Tissues by AFM
15:30-16:15	Carolin Wagner (Leipzig)	Receptor/Ligand Interactions as studied by Optical Tweezers