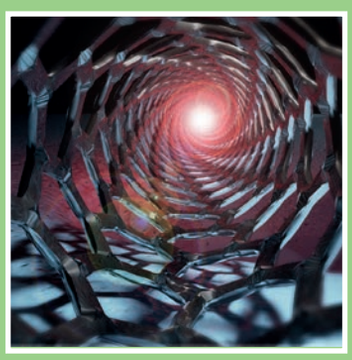
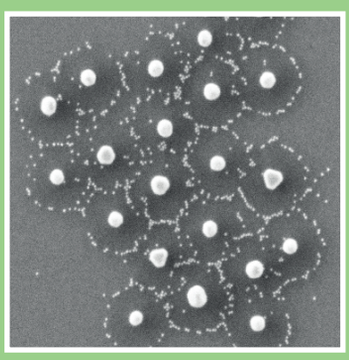
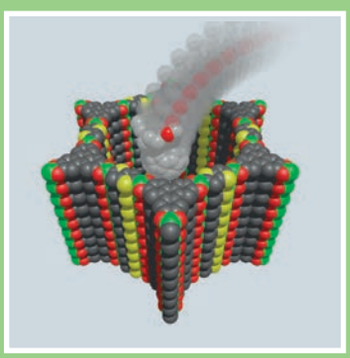
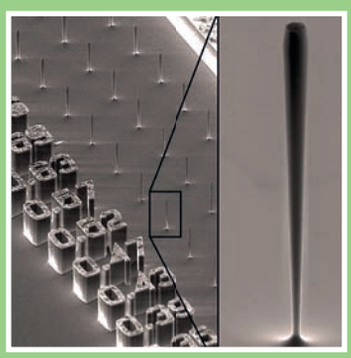
Center for NanoScience

ANNUAL REPORT 2013



CeNS
Center for NanoScience | LMU

CONTENTS

WELCOME

Over the last decade, nanoscience has achieved recognition as one of the most important research fields in the natural sciences. It has entered the public media and has become part of industrial applications. One consequence for the academic landscape is the establishment of Bachelor and/or Master degree courses in nanosciences at universities worldwide. We believe that this is a natural development resulting from the great interest in nanoscience and it will be interesting to see how education in nanoscience topics can be enhanced in our physics and chemistry curriculum in the future. Regardless of potential changes in the formal curriculum, one of the central goals of CeNS is to create an environment where students with diverse backgrounds can perform nanoscience research and are supported in the shaping of their own nanoscience curriculum.

Nanosciences not only at CeNS but all over the world rely on bright and resourceful graduate students. We are therefore proud to report on several successful events aimed specifically at bringing together young and open minds. One example is the "Global Challenges – Opportunities for Nanotechnology" workshop which took place on the island of San Servolo in Venice. Participants from 28 nations met to identify challenges from the students' perspectives and to initiate joint projects. Another success story is the Junior Nano Network (JNN). Its aim is the exchange of world-class nanoscience knowledge between graduate students from Germany and partner institutions abroad. The JNN project takes advantage of local expertise and facilities and aims to initiate scientific and personal exchange. It links the research efforts in the field of nanoscience of the two universities and fosters interaction between the partnering countries. For the 2013/2014 exchange, CeNS connected their graduate students with peers from the Center for Nanoscience and Nanotechnology at Tel Aviv University. The visiting students also participated in the CeNS Summer School in Venice – a continuing success story in its own right.

To honor the scientific achievements of its students, CeNS has announced a limited number of travel awards for the best applicants. These awards are dedicated to active participation in a scientific conference or workshop. In a competitive selection process, 12 international trips have been supported so far and we are looking forward to future applications.

We are very proud not only of the graduate students, but of all the researchers at CeNS. Many received national and international grants and awards, many were offered attractive positions at renowned universities, and many published great articles that are highlighted in this report. We are also glad to announce that our spin-off companies are doing extremely well and received several prestigious industry and business prizes in 2013. As you will see when browsing through this annual report, CeNS continues to thrive and is fulfilling its self-set goals to i) promote interdisciplinary research and education, ii) promote cooperation between different disciplines, iii) promote contacts between its members and national and international communities, and iv) cooperate with interested industry and stimulate entrepreneurship.

In 2013 an important addition was introduced to the structure of CeNS. Three student representatives were elected: Hsin-Yi Chiu, Cornelius Weig and Svenja Lippok. In addition to supporting the management team in organizing events like "Science in a Nutshell" and CeNS lab tours, they will offer us valuable insights into young researchers' experiences and requirements. A further change to the structure is the addition of a fourth and a fifth full member to the CeNS Advisory Board. Christina Scheu has left our Scientific Board. We thank her for her dedication and wish her all the best for her future. She has been replaced by Claudia Veigel who we warmly welcome.

Our gratitude goes to the CeNS management team Susanne Hennig (managing director), Marilena Pinto (program manager), and Claudia Kleylein (team assistant) for their commitment and continuous support.

Prof. Tim Liedl

Member of the Scientific Board of CeNS

NEW MEMBERS

PROF. JAN LIPFERT

LMU Munich

Prof. Jan Lipfert studied physics and economics in Heidelberg, Germany. After completing his undergraduate degree in 2000, he obtained a master's degree in Uppsala, Sweden, and another master's degree as a Fulbright fellow at the University of Illinois at Urbana-Champaign, USA, in 2002. For his Ph.D. at Stanford University, he worked with Sebastian Doniach and Daniel Herschlag, using a combination of computer simulations, bench-top biochemistry, and small-angle X-ray scattering to study the structure, dynamics, and interactions of (membrane) proteins and RNAs. In 2007, Jan joined the lab of Nynke Dekker at TU Delft as a postdoc, where he developed novel magnetic tweezers for single-molecule studies of torque and twist and applied them to investigate the properties and dynamics of DNA, RNA, and nucleo-protein filaments. Jan was appointed to a tenure-track W2 professorship in experimental biophysics at LMU in fall 2013. In Munich, he will continue to use a combination of X-ray scattering, magnetic tweezers, and other single molecule techniques and computer simulations to probe the structure, mechanics, and biological interactions of macromolecules, in particular of functional nucleic acids.

DR. JULIEN POLLEUX

MPI for Biochemistry

Dr. Julien Polleux studied physical chemistry at the University of Bordeaux and received his Diploma degree in 2002. He subsequently started his PhD studies at the MPI of Colloids and Interfaces in the group of Prof. Antonietti and Prof. Niederberger, where he studied the formation and the assembly of metal oxide nanoparticles mediated by small polydentate ligands in nonaqueous solvents. He showed how to control the assembly of functionalized anatase nanoparticles into nanowires via "oriented attachment" and elaborated fast one-step approaches to synthesize WO_{3-x} ordered nanostructures. In 2005, he decided to interface cell biology and moved to Prof. Dunn's group at UCLA, where he worked on the differentiation of pluripotent stem cells through the formation of embryoid bodies on hydrophobic self-assembled monolayers, in close collaboration with Prof. Wu. After a short stay in Prof. Spatz's lab, in 2008 he moved to Prof. Fässler's group at the MPI for Biochemistry to focus on integrin-mediated adhesion. Over the last few years, he has developed several micro/nanofabrication techniques to design functional culture substrates, which have the ability to 1) simultaneously engage different classes of cell surface receptors for cross-talk studies by using binary nanoarrays and 2) reversibly manipulate integrin binding with the help of thermoplasmonics. By combining these approaches, he aims to dynamically control the interactions between the extracellular matrix and various transmembrane receptors in order to investigate reciprocal signaling circuits with high-resolution live-cell imaging.

PD DR. MARKUS REHBERG

LMU Munich

PD Dr. Markus Rehberg studied molecular biology in Munich and graduated in 2000. During this time he received a scholarship from the German National Academic Foundation (Studienstiftung des Deutschen Volkes). He obtained his Ph.D. in 2005 with *summa cum laude* from LMU Munich, with a thesis on microtubule binding proteins, performed with R. Gräf and M. Schliwa at the Institute of Cell Biology, Munich. After a postdoctoral stay with A. Konnerth, in 2007 he joined the group of F. Krombach at the Walter-Brendel-Centre of Experimental Medicine, Munich, where he investigated interactions and effects of nanomaterials in the microcirculation. In 2013 he received the *facultas docendi* and *venia legendi* in physiology and since then has been group leader at the Walter-Brendel-Centre. Using advanced *in vivo* microscopy techniques, he investigates different novel nanoconstructs at the microscopic tissue/cell level and aims to target distinct immune cell populations, in order to control specific cellular functions.

PROF. PETRA SCHWILLE

MPI for Biochemistry

Prof. Petra Schwille studied physics and philosophy in Stuttgart and Göttingen, and graduated in 1993 with a Diploma in physics from the Georg August University, Göttingen. She obtained her Ph.D. in 1996 from the TU Braunschweig, with a thesis on fluorescence correlation spectroscopy, performed at the MPI for Biophysical Chemistry, Göttingen. After a postdoctoral stay at Cornell University, Ithaca, NY, she returned to the MPI Göttingen as a research group leader, financed by the BMBF Biofuture grant, in 1999. In 2002, she accepted a chair of biophysics at the newly established BIOTEC center of the TU Dresden. Since 2012, she has been scientific director of the Department of Cellular and Molecular Biophysics at the MPI of Biochemistry, Martinsried. Her scientific interests range from single molecule biophysics to the synthetic biology of reconstituted systems.

DR. STEFAN WUTTKE

LMU Munich

Dr. Stefan Wuttke studied chemistry at the HU Berlin and the University of Glasgow. He completed his Ph.D. in 2009 with Prof. Kemnitz at the HU Berlin. For his postdoctoral research, Stefan moved to the Institute Lavoisier de Versailles (Prof. Férey and Dr. Serre) and Laboratoire Catalyse et Spectrochimie - ENSICAEN (Prof. Daturi), supported by a Feodor Lynen grant. Since 2011, he has been working in the group of Prof. Thomas Bein at LMU Munich as a junior researcher pursuing a habilitation, supported by a Return Fellowship from the Alexander-von-Humboldt Foundation. His research concerns the synthesis, functionalization, characterization, and application of porous materials and nanoparticles, particularly structure-reactivity as well as host-guest relationships in metal-organic frameworks (MOFs) for application in the field of sensor technology and drug delivery.

MEMBERS' NEWS

CALLS & APPOINTMENTS

Prof. Patrick Cramer (LMU) accepted a position as director of the Max Planck Institute for Biophysical Chemistry in Göttingen.

Prof. Thomas Franosch (University of Erlangen) was appointed professor of theoretical physics at the University of Innsbruck.

Prof. Erwin Frey (LMU) declined an offer from the University of Austin, Texas.

Prof. Ulrich Gerland (LMU) accepted an offer as full professor (W3) for Theoretical Biophysics from the TU Munich.

Prof. Thorsten Hugel (TUM) accepted an offer as full professor (W3) at the Albert-Ludwigs-Universität Freiburg.

Prof. Dirk Metzler (Uni Potsdam) declined an offer from the University of Dundee, Scotland.

PD Dr. Rossitza Pentcheva (LMU) accepted an offer as professor for Theoretical Physics (W2) at the Universität Duisburg-Essen.

Prof. Christina Scheu (LMU) accepted an offer at the Max Planck Institute für Eisenforschung Düsseldorf with a professorship at RWTH Aachen.

Prof. Marc Tornow (TU Braunschweig) was appointed associate professor of molecular electronics at TU München.

ERC GRANTS

Prof. Alexander Högele (LMU) received an ERC Starting Grant for his project "Interfacing quantum states in carbon nanotube devices".

Prof. Tim Liedl (LMU) won an ERC Starting Grant for his research project "Optical Responses Controlled by DNA Assembly (ORCA)".

AWARDS

Prof. Jochen Feldmann (LMU) won the Nanonica Prize for the "Breakthrough of the Year 2013 in the Nanosciences".

Prof. Petra Schwille (MPI for Biochemistry) received the Suffrage Science Award 2013, MRC-CSC. In addition she became an elected member of EMBO and of the Berlin-Brandenburg Academy of Sciences and Humanities.

Prof. Friedrich Simmel (TUM) was elected as a member of the National Academy of Science and Technology (acatech).

Prof. Dirk Trauner (LMU) was awarded the 2013 Kitasato Microbial Chemistry Medal.

AWARDS

ATTOCUBE-WITTENSTEIN AWARD

Prof. Khaled Karrai (right) presented the attocube research awards to Eva-Maria Roller (2nd from right), Friederike Möller (5th from right), Dr. Thomas Faust (3rd from left) with his supervisors Prof. Jörg Kotthaus and Prof. Eva Weig, and Prof. Thomas Bein (1st from left), supervisor of Dr. Johann Feckl (missing in the picture).

On July 19, the "attocube Research Awards 2013" were given to four CeNS Master students and PhD scientists. They and their supervising groups were honored for their excellent Master's theses and PhD dissertations in the field of application-related nanosciences. The award is endowed with €17,500 and has been presented annually since 2009. Company founder and Scientific Director Prof. Khaled Karraï rewarded the students for their exceptional performance. While most scientific prizes celebrate achievements in fundamental research, the attocube Research Award attaches particular importance to the potential industrial applicability of such achievements. It promotes lateral thinking and unites scientific approaches with potential market orientation. The ability to identify chances and market potentials and to make the entrepreneurial step to turn them into reality is one of the pillars of attocube's success. Karraï gave the prize to the awardees stating: "It is essential for attocube to promote the interdisciplinary exchange between science and industry, thus opening up new potentials which will create opportunities we can't even detect today. The attocube Research Award rewards young scientists opening up their minds to application-oriented approaches and facilitating the exchange of different disciplines."

Master's Thesis Category:

Eva-Maria Roller (Prof. Tim Liedl's group): Her thesis focuses on the development of a new concept to produce DNA-based "metamaterials". Such novel materials have unusual optical properties that can be finely tailored. The potential here is in optical information processing.

Friederike Möller (Prof. Philip Tinnefeld's group) received the award for her work on DNA origami, designed to build nano-electromagnetic antenna that amplify the intensity emission of fluorescent molecules by about more than 100 times. The potential for this work is in medical diagnostics and DNA sequencing.

Dissertation Category:

Dr. Johann Feckl (Prof. Thomas Bein's group) worked on novel nanostructures made of nanocrystals of lithium-titanate crystals that make it possible to store electrical energy in such a way that charging speed and charging stability are enormously enhanced. This novel system will fill the gap between conventional batteries and supercapacitors.

Dr. Thomas Faust (Prof. Jörg Kotthaus and Prof. Eva Weig's group) developed a novel compact plug-and-play sensor architecture out of nano-mechanical strings that integrates the sensors and their microwave readout, making them much easier to use than ever. These sensors are very sensitive to environmental changes possibly down to single-molecule detection.

www.cens.de/research/attocube-research-award/

CENS PUBLICATION AWARDS

In 2013, CeNS awarded 20 prizes for excellent publications by CeNS members that were published during the past twelve months. Successful CeNS internal collaboration projects, such as those between the groups of Prof. Jan von Delft and Dr. Stefan Ludwig or between Prof. Thomas Bein and Prof. Achim Hartschuh, were amongst those that received an award.

Prof. Jörg Kotthaus (here with CeNS board members Prof. Claudia Veigel and Prof. Tim Liedl) was the happy winner of two publication awards, for a publication in Nature Physics together with Prof. Eva Weig and a paper in Phys. Rev. Lett. together with Prof. Alexander Holleitner.

In addition, outstanding articles from individual research groups which were published in renowned journals such as Nature, Nature Physics, Phys. Rev. Lett. or PNAS were recognized. The winning publications are highlighted in "Selected publications" section of this report (page 37ff). The announcement of the winners took place at the CeNS Come-Together-Event in November.

www.cens.de/research/cens-publication-award

The CeNS band "UnCeNSiert" playing at the CeNS Come-Together Event 2013 (from left to right Maren Reichl, Dr. Hanna Engelke, Dr. Martin Hennig).

SPIN-OFF NEWS

ATTOCUBE

Attocube systems was placed second in the renowned **TOP100 innovation award**, which is presented annually to the most important innovation drivers in the country. Furthermore, attocube systems received the **IVAM Marketing Award 2013** at the Hannover Messe. The award is given for extraordinary and creative marketing concepts in the microtechnology sector.

www.attocube.com

CHROMOTEK

Push For Smart Industry: Chromotek was the successful winner of the **Industriepreis 2013** competition. It was selected from 1,200 participating companies not only as the winner of the biotechnology category, but also as the overall winner for the Chromobody technology for the detection of endogenous proteins in living cells. The "Industriepreis" has beeen awarded since 2006 for applications with particularly high economical, social, ecological, or technological impact.

www.chromotek.com

GNA BIOSOLUTIONS

Together with two other companies, GNA Biosolutions GmbH shared the **German Venture Award 2013**, awarded by the Private Equity Forum NRW e.V.
GNA Biosolutions GmbH convinced the professional audience with their business concept.

www.gna-bio.de

NANOTEMPER

NanoTemper Technologies was the **winner of the Bavarian Export Prize 2013** in the "Industry" category. This prize acknowledges NanoTemper's success in introducing the MicroScale Thermophoresis (MST) technology into markets worldwide. The Microscale Thermophoresis Technology (MST) from Nanotemper was selected as the winner of the **Quantum Design Best Recognized New Technology (BRNT) Award for the Chinese market in 2012**. The BRNT award from Quantum Design International is selected from all the new technologies of QDC business partners. It speaks highly about how well a new technology and related product are perceived in the R&D community.

www.nanotemper.de

IBIDI

ibidi GmbH received the **2013 Innovationspreis der Deutschen Wirtschaft** (German Economy Innovation Award), in the "Medium-Sized Business" category, for its unique cell biochips made from high-performance polymers. The prize acknowledges the most important scientific, technical, entrepreneurial, and intellectual innovations. With the development of the new cell biochips, ibidi has made it possible for the first time to use plastic as a material for bio-slides that can simulate an organ-like environment. ibidi's cell biochips have also been acknowledged in more than 1,500 technical publications. With its plastic slides for live cell analytics, the company leads the world-wide market in this area.

www.ibidi.de

NEASPEC

Neaspec won the **STEP award competition 2013** for the best product and technology. The judges emphasized that the prize was awarded to Neaspec, because its product and technology has the potential to become a champion in the field of chemical nano-analytics. The STEP award aims to stimulate companies in their growth phase and thus to ensure successful future development. In addition, nano-FTIR from Neaspec won the prestigious **Microscopy Today Innovation Award 2013**. The prize is awarded annually to the top international innovations in microscopy that make imaging and analysis more powerful, more flexible, more productive, and easier to accomplish. Furthermore, Neaspec was selected as a **top 10 finalist of the Deutscher Gründerpreis 2013**, Germany's most prestigious start-up award.

www.neaspec.com

NEW CHIRAL MARKERS FOR MICROSCOPY

Since the end of 2013, Prof. Tim Liedl and LMU Master's student Timon Funck, in cooperation with the company STS Nanotechnology, have started the commercialization of gold nanohelices. The structures are produced by DNA origami technology and can be used as chiral nanoscale markers especially suited for 3D Tomography/Electron Microscopy (EM)/ CryoEM. The gold nanohelices are commercially available via the company Science Services and STS Nanotechnology.

http://scienceservices.eu/en/gold-nanohelices-30-l.html
mail@sts-nano.com

EVENTS & ACTIVITIES

GLOBAL CHALLENGES - OPPORTUNITIES FOR NANOTECHNOLOGY

Between April 15th and 18th, CeNS, the Swiss Nanoscience Institute Basel, and the ETH Zürich organized a workshop with the aim of raising the next generation of nanoscientists' awareness of the global challenges looming on the horizon. Postdocs and senior PhD students from a broad range of countries from all continents were invited with the goal of initiating a global network. The meeting gathered 57 participants with 28 nationalities from all continents. Their scientific backgrounds, though nanoscience-oriented, ranged from physics and chemistry to life sciences and also included engineering and IT disciplines. Particular emphasis was placed on inviting students from developing and threshold countries, as well as on ethnic and gender balance. In addition, an expert team was invited to support the discussions. Two Nobel laureates, Jean-Marie Lehn and Gerd Binnig, Viola Vogel (the former US presidential advisor on nanotechnology), and Adi Scheidemann, a nanotechnology entrepreneur, contributed detailed knowledge and know-how.

The first part of this meeting was designed to foster awareness of the global situation by analysis by this group of junior scientists. In the next round, the participants identified key problems where nanotechnology and nano- and bioengineering can help. The last and possibly most important part was that the researchers formed interdisciplinary networks, working out detailed concepts on how the most urgent global challenges can be targeted using nanotechnology and bioengineering. Since any change requires internationally concerted efforts, the initiation of a network amongst those scientists who will shape our scientific and technological future seemed essential. This goal was supported by creating an interactive WIKI-based platform for further networking and exchange of ideas between the participants. In addition, a summary of all ideas and results obtained by the interdisciplinary groups was published in a booklet which was sent to international stakeholders from science and politics, funding bodies, and NGOs.

www.cens.de/international/joint-workshops/globalchallenges13

CENS MEETS INDUSTRY

What comes next after the PhD? To present diverse career paths and employment opportunities to the junior scientists of CeNS, CeNS invited representatives and alumni from industry and various business sectors to "CeNS meets Industry 2013". The program was very diverse with representatives from a range of business sectors. The first session with Dr. Stefan R. Huebner (patent attorney), Dr. Carolin Tolksdorf (Bosch Venture Capital GmbH) , and Dr. Tilman Huhne (d-fine GmbH) presented career opportunities for scientists in the IP, venture capital investment, and consulting sector. In the second part, Dr. Christian Russ (Intel Mobile Communications GmbH) and Dr. Daniel Harbusch (EPCOS AG) spoke about career paths in research and development. Last but not least, Prof. Kevin Kelly from Rice University reported about his personal start-up experiences in his talk "Compressive Imaging: Is a single pixel camera useful?" The event was followed by the traditional CeNS summer party, where the presentation of the attocube awards 2013 by Prof. Khaled Karrai took place (see page 6). The Salinenhof at the Faculty of Physics on a beautiful summer evening was the ideal setting for discussions between CeNS members, speakers, guests, and alumni in a relaxed atmosphere.

www.cens.de/calendar/past-workshops-events/cens-meets-industry-2013/

CeNS members Prof. Dieter Braun, Prof. Thomas Bein and Prof. Erwin Frey discussing with the Prof. Axel Schenzle, Dean of the Faculty of Physics.

Participants of the "Global Challenges" workshop in Venice/San Servolo.

CENS WORKSHOP VENICE 2013

"Nanosciences: Great Adventures on Small Scales" - this was the motto of the annual CeNS workshop in 2013 on the island of San Servolo, Venice. The varied program covered a wide range of nano-science topics from nanomaterials, quantum photonics and plasmonics to nanobioscience and synthetic biology with contributions from renowned speakers from all over the world: David Awschalom, Jeremy Baumberg, Steven Benner, Luisa De Cola, Cees Dekker, Eric Greene, Karl-Peter Hopfner, Atac Imamoglu, Frank Jülicher, Philipp Kukura, Konrad Lehnert, Stanislaw Leibler, Sua Myong, Laura Na Liu, David Nelson, Oskar Painter, James Schuck, Joachim Spatz, Shimon Weiss and Hiroshi Yamaguchi. In addition, four researchers from CeNS (Alexander Holleitner, Madeleine Opitz, Jan Lipfert, and Frank Jäckel) presented their research.

For the first time, this year's attocube awardees (see page 6) were invited to Venice as speakers. Two of them, Friederike Möller and Dr. Thomas Faust, took advantage of this opportunity and gave a talk about their prize-winning work. Moreover, CeNS graduate students, including Junior Nanotech Network participants from Munich and Tel Aviv (see page 10), presented and held a lively discussion of their latest results during the two poster sessions.

www.cens.de/calendar/past-workshops-events/venice-2013

Lively discussions during the poster session in Venice.

FOCUS WORKSHOPS

Several focus workshops organized by CeNS members were supported by CeNS in 2013. Together with the Abdus Salam International Centre for Theoretical Physics (ICTP) and the Nanosystem Initiative Munich (NIM), CeNS member Dr. Stefan Ludwig co-organized a workshop on **"Interferometry and interactions in non-equilibrium meso- and nanosystems"** at the ICTP in Trieste from 8 - 12 April 2013. The fields of quantum interference and interactions in meso- and nano- out-of-equilibrium systems are both rapidly developing and of decisive importance for the development of semiconductor-based quantum information technology. The goal of the workshop was to bring together leading experimentalists and theorists to consolidate the expertise of the two still mostly separate fields.

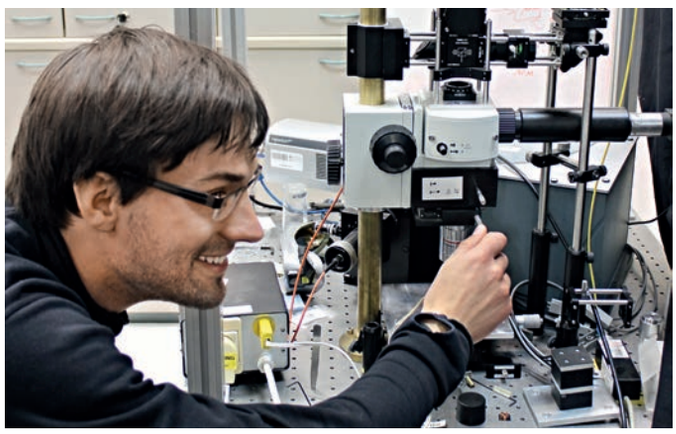
In autumn another CeNS-supported workshop was held at ICTP Trieste: **"Frontiers of Nanomechanics"** was co-organized by CeNS members Prof. Eva Weig, Prof. Jan von Delft and Prof. Florian Marquardt. Between September 9 and 13, international experts from the expanding field of nanomechanics presented their latest results. The focus of the workshop was on topics such as nano-electro- as well as nano-optomechanical systems, and hybrid as well as monolithic devices, covering both the classical and the quantum regime.

CeNS also supported the PhD symposium **interact2013** which took place in March 2013. interact, organized entirely by PhD students and covering all research institutions in the Munich area, has firmly established itself as a great event for PhD students in the field of life sciences. Each year, CeNS associates participate actively in the program and its organization.

www.cens.de/calendar/past-workshops-events/

JUNIOR NANOTECH NETWORK (JNN) 2013/14

In 2013, the fifth Junior Nanotech Network (JNN) was organized by CeNS. The aim of this program is to promote exchange of world class nanoscience knowledge between graduate students from different institutions worldwide. This time, the JNN was initiated by Prof. Hermann Gaub (CeNS) and by Prof. Michael Urbakh (Center for Nanoscience and Nanotechnology at Tel Aviv University). The JNN was financially supported by the German-Israeli Project Cooperation.



Peter Röttgermann (CeNS) during the lab rotations.

The first part of the JNN was held from September 9 to 28 in Munich, Venice, and Bayreuth and was coordinated by CeNS. Eight PhD students from Tel Aviv received a warm welcome from their host students from LMU Munich, TU Munich, the University of Augsburg, and the University of Bayreuth. After a welcome breakfast on the first day, the students immediately immersed themselves in the different lab projects. Small groups of one or two Israeli students visited their German hosts and performed hands-on experiments in the labs on topics such as single molecule FRET, lab-on-a-chip techniques, cell adhesion on functionalized implant surfaces and much more. The second week brought another highlight of the program: All students took part in the CeNS workshop "Nanosciences – Great Adventures on Small Scales" on the beautiful island of San Servolo (see page 9) and presented their projects in the poster sessions. In addition, there was ample opportunity

Hiking trip in the Alps.

for discussions with international speakers and CeNS members in the charming atmosphere of Venice. After their return to Munich, the students continued with two more days of lab rotations. The last part of the program was a 3-day practical course on advanced light microscopy "Cellular Dynamics on the Nanoscale", organized and hosted by Prof. Matthias Weiss at the University of Bayreuth. Both CeNS and Tel Aviv students attended the workshop which consisted of a mix of theoretical input by four keynote speakers and practical training.

Beside the scientific program, the JNN participants also enjoyed social activities such as sightseeing in Munich, a trip to the Alps, and the vivid atmosphere of the Oktoberfest. Strong ties between German and Israeli students were established not only by these educational and social activities but also by the housing concept, since private accommodation for almost all guests was provided by the host students. The first part of the JNN 2013/14 was a true scientific as well as social success for all participants. The return visit of the CeNS students to the Center for Nanoscience and Nanotechnology at Tel Aviv University was scheduled for January/February 2014, and a report will be included in the 2014 Annual Report.

www.cens.de/international/exchange-programs/jnn/

JNN 2013, from left to right: Lena Voithenberg, Or Berger, Tanya Levi Belenkova, Assaf Grunwald, Wolfgang Ott, Sarah Kesel, Adar Sonn, Thomas Suren, Klara Malinowska, Ayelet Amsalem, Peter Röttgermann, Andreas Veres. Not in the picture: Yonatan Adalist, Lilach Bareket-Keren, Matthias Lischka, Melanie Stamp, Eitam Vinegrad.

Lena Voithenberg (CeNS) and Yonatan Adalist (TAU) during the lab rotations in Munich.

PHD STUDENTS' CORNER

CENS TRAVEL AWARDS

Since 2013, CeNS has been announcing a limited number of travel awards for its graduate students and postdocs. These awards are dedicated to active participation in a scientific conference or workshop. In a competitive selection process, 12 international trips were supported in 2013. Three examples are described here:

After developing a new experimental technique to image the distribution of defects in organic thin films, **Christian Westermeier** (Dr. Bert Nickel's group) got the chance to present his results at the Fall Meeting 2013 of the Materials Research Society (MRS) on December 1-6 in Boston, USA. As a reward for his work he was named a "Best Poster" nominee, gaining the opportunity to advertise the new experimental approach to a broad audience. The basic concept of the experiment is first to fill the trap states inside the channel of an organic field-effect transistor (OFET) by the gate voltage. Second, pulsed illumination with the wavelength that corresponds to the first S0-S1 excitation of the material in focus (pentacene) induces a local release of the trapped charge by exciton-assisted trap clearing. Detection of this charge release occurs via frequency-resolved photoresponse measurements and allows direct imaging of the trap density in ordered thin films of conjugated molecules, a crucial insight for the improvement of organic electronic devices.

Nina Mauser (Prof. Hartschuh's group) presented her results on antenna-enhanced optoelectronic probing of carbon nanotubes in a talk at the MRS Fall Meeting 2013 in Boston. Using a gold tip as an optical antenna one can locally enhance the absorption or emission of a nanostructure, achieving sub-diffraction spatial resolution. Using this principle Nina demonstrated imaging of optoelectronic signals such as photocurrent and electroluminescence in carbon nanotube devices with a spatial resolution of 30 nm. She showed a very high confinement of the electroluminescence appearing at a nanotube crossing to a length of smaller than 10 nm. In addition, revealing a spatial correlation between the electroluminescence and the photocurrent at the crossing indicates that the mechanism responsible for the electroluminescence is impact excitation.

Robert Schreiber (Prof. Tim Liedl's group) presented unpublished results about "Switchable Plasmonic Nanostructures" at the "Programmable Self-Assembly of Matter" conference in New York City in June 2013. Together with scientists from Boise State University (USA) and Ohio University (USA), he used the DNA origami technique to arrange plasmonic nanoparticles into nanoscale helices. By switching the orientation of the nanoparticle helices it was possible to dynamically control the optical activity of the composite material. The observed circular dichroism signals are reversible and can be explained qualitatively and quantitatively by plasmonic dipol theory. Robert received a Nature Materials Poster Award for his poster presentation at the conference.

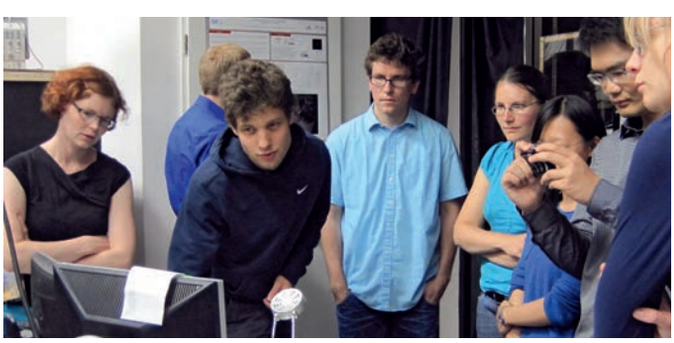
See all awardees here: *www.cens.de/research/cens-travel-award/*

CENS STUDENT REPRESENTATIVES

The CeNS associates (Master's students, PhD students, and postdocs) are an integral part of CeNS. To plan and offer CeNS activities in close collaboration with the associates, three CeNS student representatives were elected by the associates for the first time in 2013: Hsin-Yi Chiu (chemistry department), Svenja Lippok, and Cornelius Weig (both physics department). Hsin-Yi, Svenja, and Cornelius served as contact persons for all CeNS associates and the CeNS management. They initiated and organized student-related events such as the new lab tours (see below) or the well-established "Science in a nutshell". We thank them for their commitment!

CENS LAB TOURS

As a PhD student, it can be extremely useful to know what is going on next door - but sometimes it might be difficult to find out. To foster interactions within CeNS, the student representatives initiated a new peer-to-peer event, the CeNS lab tours. The first part in May was devoted to the LMU physics department, where about 18 students were guided through the labs by peer PhD students and learned about research and infrastructures at the chairs of Prof. Feldmann, Prof. Gaub, Prof. Rädler and Prof. Kotthaus. The second part took place at the LMU chemistry department in Großhadern in July. The labs involved were those of Prof. Carell, Prof. Bein, Prof. Lamb, and Prof. Wagner. The tour was followed by a student-organized barbecue on the campus. Last but not least, the CeNS students made their way to Garching in late August to visit the labs of Prof. Rief, Prof. Hugel, Prof. Simmel, and Prof. Holleitner at TU München. The lab tours were a great success and a perfect way to meet new people and to discuss new ideas within CeNS.

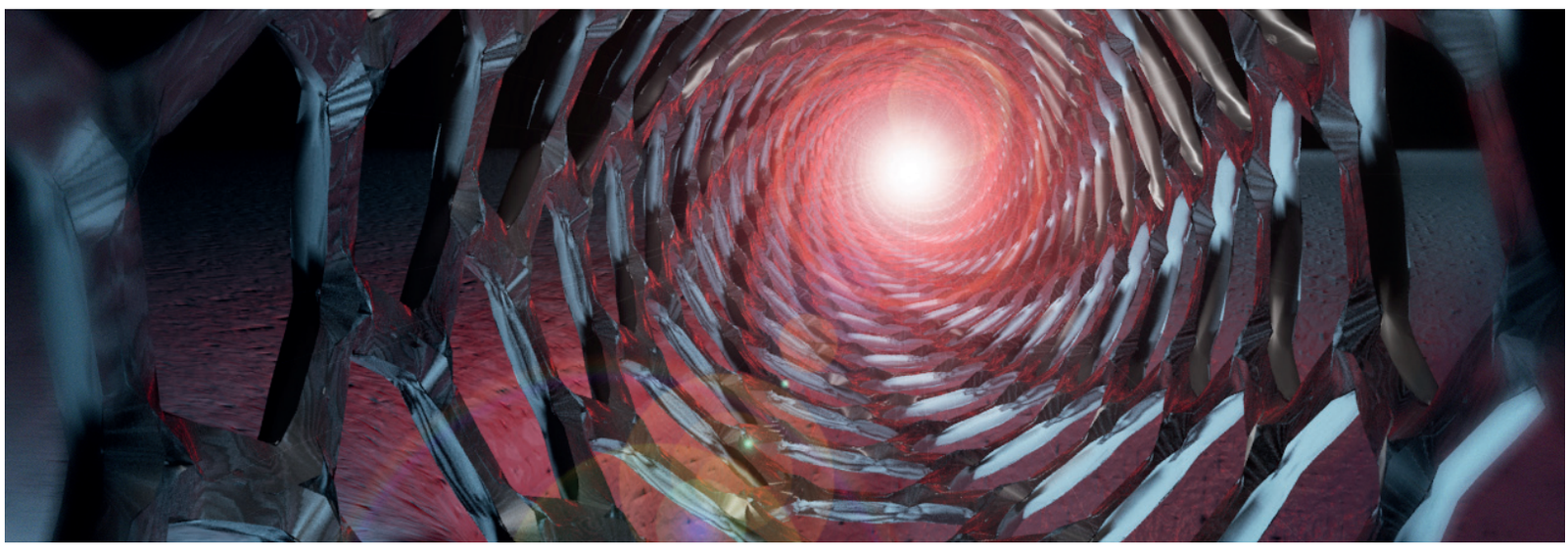


KEY QUALIFICATION WORKSHOPS

CeNS supported its associates with several key qualifications workshops. An online poll was done to find out which topics were most important for the associates. As a result, a workshop on **"Project management for scientists"** was offered to graduate students and postdocs in March 2013, and a second two-day workshop **"Optimizing Writing Strategies for Getting Published in English"** was organized in October. Both workshops turned out to be very popular among the students. To broaden their entrepreneurial skills, CeNS PhD students and postdocs had the opportunity to attend the three-day **Entrepreneurship Seminar** organized by the LMU Entrepreneurship Center in November 2013.

www.cens.de/calendar/past-workshops-events/

SELECTED RESEARCH PROJECTS



COHERENT CONTROL OF A CLASSICAL NANOMECHANICAL TWO-LEVEL-SYSTEM

Prof. Eva M. Weig (University of Konstanz, Faculty of Physics) *www.nano.uni-konstanz.de*
Prof. Jörg P. Kotthaus (LMU Munich, Faculty of Physics) *www.nano.physik.uni-muenchen.de*

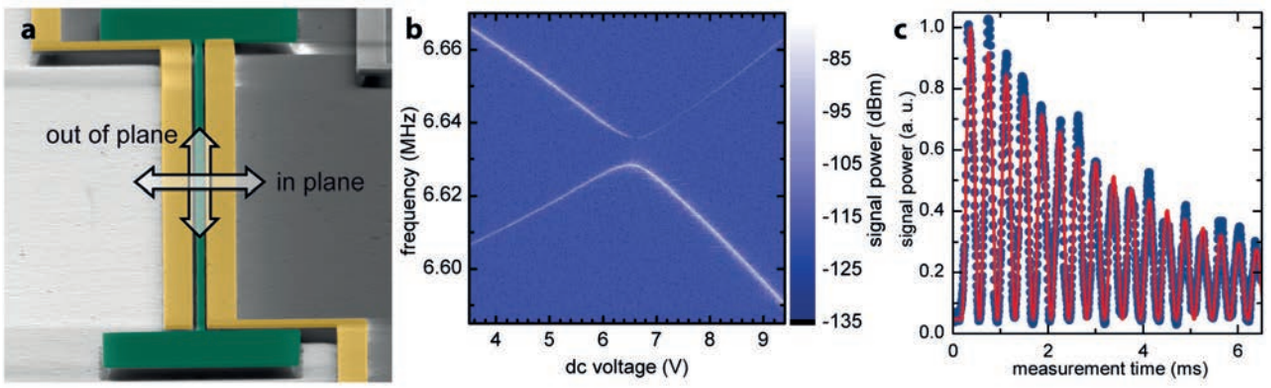


Figure 1. *a: The silicon nitride string resonator (green) with adjacent gold electrodes. The arrows denote the oscillation directions of the two fundamental flexural modes (in-plane and out-of-plane). b: Avoided crossing of the two strongly coupled modes when tuned with a dc bias. c: Rabi oscillations between the two hybridized normal modes at the point of zero detuning.*

In the rapidly advancing field of nanomechanics, coupled mechanical resonators have recently attracted considerable interest as model systems for coherently coupled oscillators. Expected to exhibit rich collective dynamics such oscillator arrays can also be utilized in information processing. Realizing a simple, yet tunable nanomechanical resonator with coherence times beyond 100.000 oscillation periods has now allowed to systematically explore the dynamics of two coupled resonator modes.

The resonator is a strongly taut silicon nitride string embedded in and dielectrically coupled to a microwave cavity via two gold electrodes. These enable heterodyne electrical read-out of the mechanical motion and also facilitate electrical actuation and tuning of flexural mechanical resonances. The two fundamental modes, oscillating at around 6 MHz in the out-of-plane and in-plane direction (Fig. 1a), are linearly coupled by cross-derivatives of the inhomogeneous electric field between the electrodes. When the initially dissimilar resonance frequencies of the two modes are voltage-tuned to the point of zero detuning, a pronounced avoided crossing reflects the strong coupling between the modes (Fig. 1b). Sweeping the system, previously initialized in a well-defined oscillation state, through the coupling region with different velocities, classical Landau-Zener transitions can be studied. Furthermore, the transitions between the two modes at the point of zero detuning can be pumped, thus making the system perform Rabi oscillations (Fig. 1c). Via Ramsey and Hahn echo experiments, the energy and phase relaxation rates of the coherent superposition states are extracted, revealing that the coherence is solely limited by energy relaxation to the environment.

Such coherent manipulation of a coupled mechanical system allows the simulation of quantum systems using classical resonators. Furthermore, in light of the recent breakthrough in ground-state cooling of nanomechanical resonators, these schemes can be directly transferred to quantum nanomechanical systems, where they open up a new route to quantum information processing.

T. Faust, J. Rieger, M.J. Seitner, J.P. Kotthaus, E.M. Weig: *Coherent control of a classical nanomechanical two-level-system;* Nat. Phys. 9, 485 (2013).

ANALYSIS OF 5-(HYDROXYMETHYL)-CYTOSINE PROTEIN READERS USING MODERN MS BASED PROTEOMICS

Prof. Thomas Carell (LMU Munich, Departmemt of Chemistry) *www.carellgroup.de*
Prof. Heinrich Leonhardt (LMU Munich, Department of Biology) *www.bioimaging.bio.lmu.de/research/research-group-leonhardt*

Tet proteins oxidize 5-methylcytosine (mC) to generate 5-hydroxymethyl (hmC), 5-formyl (fC) and 5-carboxylcytosine (caC). The exact function of these oxidative cytosine bases remains elusive. We applied quantitative mass spectrometry-based proteomics to identify readers for mC and hmC in mouse embryonic stem cells (mESC), neuronal progenitor cells (NPC) and adult mouse brain tissue. Readers for these modifications are only partially overlapping and some readers, such as Rfx proteins, display strong specificity. Interactions are dynamic during differentiation, as for example evidenced by the mESC-specific binding of Klf4 to mC and the NPC-specific binding of Uhrf2 to hmC, suggesting specific biological roles for mC and hmC. Oxidized derivatives of mC recruit distinct transcription regulators as well as a large number of DNA repair proteins in mouse ES cells, implicating the DNA damage response as a major player in active DNA demethylation.

C.G. Spruijt, F. Gnerlich, A.H. Smits, T. Pfaffeneder, P.W.T.C. Jansen, C. Bauer, M. Münzel, M. Wagner, M. Müller, F. Khan, H.C. Eberl, A. Mensinga, A.B. Brinkman, K. Lephikov, U. Müller, J. Walter, R. Boelens, H. van Ingen, H. Leonhardt, T. Carell, M. Vermeulen: *Dynamic readers for 5-(hydroxymethyl)cytosine and its oxidative derivatives;* Cell 152, 1146-59 (2013).

RECONSTITUTION OF PROTEIN GRADIENT OSCILLATIONS IN ARTIFICIAL MEMBRANE COMPARTMENTS

Prof. Petra Schwille (MPI for Biochemistry, Martinsried) *www.biochem.mpg.de/en/rd/schwille*

In our strive to identify and reconstitute a minimal cell division machinery, we have been concerned with the MinCDE proteins from *E.coli*, a system which displays the fascinating feature of temporally oscillating between the poles of the cell on a minutes time scale. Reconstituted in vitro in the presence of a supported membrane, the Min proteins show remarkable dynamic pattern formation in the form of travelling waves, which can orient themselves by sensing the geometrical features of the membrane. So far however, the reconstitution of true oscillation in closed compartments has been elusive. Here we demonstrate, for the first time, under which experimental conditions true Min oscillations can be obtained, and suggest how they can be utilized to unravel the geometry dependence of the bacterial cell division machinery, or to generally act as a pacemaker for cellular processes in space and time.

K. Zieske, P. Schwille: *Reconstitution of Pole-to-Pole Oscillations of Min Proteins in Microengineered Polydimethylsiloxane Compartments;* Angew. Chem. Int. Ed. Engl. 52, 459-462 (2013).

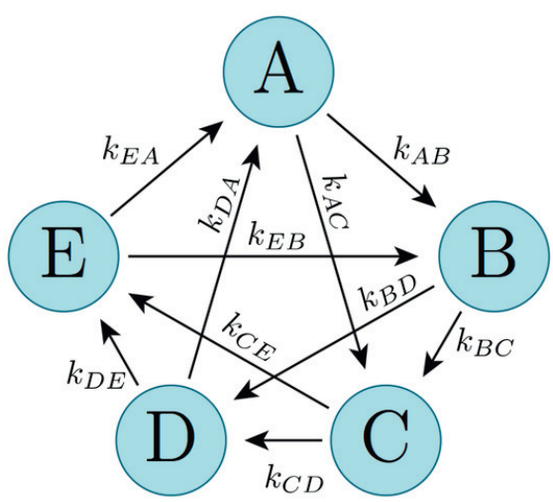
COEXISTENCE AND SURVIVAL IN CONSERVATIVE LOTKA-VOLTERRA NETWORKS

Prof. Erwin Frey (LMU Munich, Faculty of Physics) *www.theorie.physik.uni-muenchen.de/lsfrey*

Understanding the stability of ecological networks is of pivotal importance in theoretical biology. An intriguing question is how coexistence and extinction of species depend on the interaction between the species. Is it the topology of the network that sets the level of biodiversity? And how important is the strength of a single interaction link? One paradigm to address these biologically relevant questions from a theoretical point of view is the conservative Lotka-Volterra system. Furthermore, conservative Lotka-Volterra systems arise in the framework of evolutionary game theory for zero-sum games in which the payoff of the winner equals the loss of the defeated. The rock-paper-scissors scenario (where paper wraps rock, scissors cuts paper, and rock crushes scissors) represents such a zero-sum game.

In this work, the long-time behavior of conservative Lotka-Volterra dynamics was investigated for interaction networks of arbitrarily many species. Revealing the interplay between the network structure and the strengths of its interaction links on coexistence and survival scenarios was central to this study. It was shown that the nonlinear dynamics problem can be mapped to an algebraic problem. By employing the algebraic concept of the Pfaffian, which is a version of the determinant tailored to antisymmetric matrices, conditions for the coexistence of all species and conditions for the extinction of species were formulated.

Our findings were illustrated for a noncyclic network of four species in which all species coexist. Furthermore, the possible survival scenarios for the general network with five competing species were identified. These networks recently gained attention in terms of the rock-paper-scissors-lizard-spock game. Finally, consequences of the deterministic analysis for the stochastic dynamics in finite populations were discussed. A generalized scaling law for the extinction time in the vicinity of critical reaction rates was found.



The rock-paper-scissors-lizard-spock network. Our work shows under which conditions all species coexist in such a conservative Lotka-Volterra network.

Our results underline the relevance of conservative Lotka-Volterra networks as a reference for the analysis of other Lotka-Volterra models in theoretical biology and evolutionary game theory.

J. Knebel, T. Krüger, M. F. Weber, E. Frey: *Coexistence and survival in conservative Lotka-Volterra networks;* Phys. Rev. Lett. 110, 168106 (2013).

ACTIVITY MODULATION OF PROTEASE 3

Prof. Dieter Braun (LMU Munich, Faculty of Physics) *www.biosystems.physik.uni-muenchen.de*

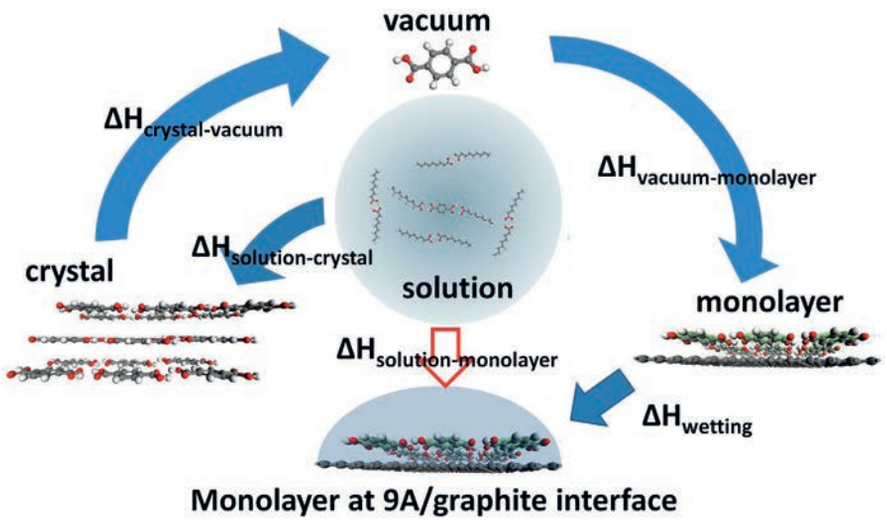
In a collaboration with immunologist Dieter Jenne (not member of CeNS), we could provide evidence for an active perturbation of Protease 3, showing a possible path to a disease treatment of the autoimmune diseases of systemic vasculitis. Central to the study were binding measurements using microscale thermophoresis.

L.C. Hinkofer, S.A.I. Seidel, B. Korkmaz, F. Silva, A.M. Hummel, D. Braun, D.E. Jenne, U. Specks: *A monoclonal antibody (MCPR3-7) interfering with the activity of proteinase 3 by an allosteric mechanism;* Journal of Biological Chemistry 288, 26635-26647 (2013).

QUANTITATIVE THERMODYNAMICS OF SUPRAMOLECULAR MONOLAYER SELF-ASSEMBLY

Dr. Markus Lackinger & Prof. Wolfgang M. Heckl (TU Munich, Department of Physics, TUM School of Education and Deutsches Museum) *www.2d-materials.com/*

This research project tackles a very important and fundamental research question in monolayer self-assembly at the liquid-solid interface: What is the overall enthalpy difference between initial and final state, i.e. molecules dissolved in solution and molecules incorporated in monolayers? Although this is the most decisive quantity for understanding the thermodynamics of monolayer self-assembly, this important research question has not been satisfactorily addressed so far, the reason being that a direct measurement is virtually impossible. The group of Lackinger and Heckl thus proposes and indirect measurement via an adapted Born-Haber cycle as schematically depicted. The overall enthalpy difference (red arrow) is evaluated through a detour via defined reference states as crystal, single molecules in vacuum, and monolayers in vacuum (blue arrows). Experimentally, the sublimation enthalpy, the dissolution enthalpy, and the monolayer binding enthalpy are measured. All experimental enthalpy values are in accord with theoretical values as obtained from molecular mechanics and molecular dynamics simulations. This perfect agreement confirms the interchangeability of experimental and theoretical enthalpy values, and hence paves the road for implementation of experimental-theoretical hybrid Born-Haber cycles with a more general applicability. Precise knowledge of the overall enthalpy change also offers experimental access to the overall entropy change. Benchmarking with theoretical values facilitates evaluation and further development of urgently needed theoretical models for entropy calculation. The results of the chosen model system reveal an astonishingly drastic reduction of the enthalpy difference by the presence of the liquid phase, thereby rationalizing many experimental observations. The proposed method is widely applicable to other systems and will be used to obtain a quantitative understanding of monolayer self-assembly thermodynamics on more general grounds.



Scheme of the proposed Born-Haber cycle. $\Delta H_{sol\text{-}monolayer}$ (red arrow) is not directly accessible, but a detour via crystal, vacuum, and unsolvated monolayer (blue arrows) as defined reference states facilitates quantification of the overall enthalpy difference.

W. Song, N. Martsinovich, W.M. Heckl, M. Lackinger: *Born-Haber Cycle for Monolayer Self-Assembly at the Liquid-Solid Interface: Assessing the Enthalpic Driving Force;* J. Am. Chem. Soc. 135, 14854 (2013).

DIFFUSION REGULATION IN BIOLOGICAL HYDROGELS

Prof. Oliver Lieleg (Institute of Medical Engineering, TU Munich) *www.imetum.tum.de/forschung/biologische-hydrogele*

Biological hydrogels establish selective diffusion barriers at various locations in the human body. Prominent examples are the basal lamina separating the blood vessels from the connective tissue and the mucus gel coating all wet epithelia such as the oral cavity, the stomach or the female genital tract. These gels share a common goal, i.e. allowing the diffusive penetration of certain particles and molecules while rejecting many others. The diffusion of particles and molecules in those complex biological hydrogels is regulated by a broad range of factors including geometric constraints and different types of physical interactions between the particles and the hydrogel constituents. As a consequence, the particle/molecule mobility depends not only on the hydrogel microarchitecture but also on the detailed chemical composition of the hydrogel solvent. Nanoparticles are a useful tool for probing the local permeability of hydrogel materials. In this project, single particle tracking experiments with high spatial and temporal resolution were used to quantify the diffusion behavior of submicrometer-sized particles in basal lamina gels. With this technique, three states of colloid mobility could be observed: free diffusion, tightly and weakly bound particles. In addition, also transitions between those states were described demonstrating the dynamic process of particle binding and unbinding during the diffusion process. By comparing the efficiency of particle trapping in the hydogel as a function of the ionic strength of the hydrogel buffer, ion-specific effects were shown to regulate the efficiency of this trapping process. These findings demonstrate how in a complex biological hydrogel such ion-specific effects can be used to "switch on" diffusive processes in a selective barrier.

F. Arends, R. Baumgaertel, O. Lieleg: *Ion-Specific Effects Modulate the Diffusive Mobility of Colloids in an Extracellular Matrix Gel;* Langmuir, 29 (51): 15965-15973 (2013).

IN SITU STM OF THE ETHYLENE EPOXIDATION ON Ag SURFACES

Prof. Joost Wintterlin (LMU Munich, Department of Chemistry) *www.cup.uni-muenchen.de/pc/wintterlin*

How does the surface of an operating catalyst look like on the atomic scale? Surprisingly, this is hardly known, despite of the importance of catalysis - the majority of chemicals made by industry are produced by heterogeneous catalysis in at least one synthesis step. Almost all information available stems from surface investigations performed under ultra-high vacuum conditions. The problem is that the findings from these studies have to be extrapolated over more than 10 orders of magnitude of pressure to the conditions of industrial processes. In how far this extrapolation is valid is an open question. This project uses scanning tunneling microscopy (STM), one of the few techniques that can be applied under conditions close to those in industrial processes. Hence, STM can, at least in principle, image the surface of a catalyst under reaction conditions with atomic resolution. However, because of many practical problems, such experiments are very demanding.

As an example the reaction of ethylene with oxygen on a silver surface to give ethylene epoxide has been investigated. The chemical industry produces 19 million tons of ethylene epoxide per year by this process. Fig. 1 shows STM images of a silver single crystal surface in an ethylene/oxygen atmosphere under conditions where ethylene epoxide formation is detected. In the top image one can see an atomically flat terrace, covered by small, dark "dashes", indicating a fluctuating surface structure. The bottom image from another surface area shows regular stripes. It turns out that the same two phases can be prepared in vacuum (fig. 2). The left image shows two areas, one displaying dark, irregular dashes, the other a stripe structure. The right image is a close-up of the stripe structure that has the same periodicity as the stripe structure under reaction conditions. For these two structures there is spectroscopic evidence that they are related to the formation of ethylene epoxide. The images of fig. 1 thus show the surface phases present on the operating silver catalyst, essential information for understanding the reaction mechanism.

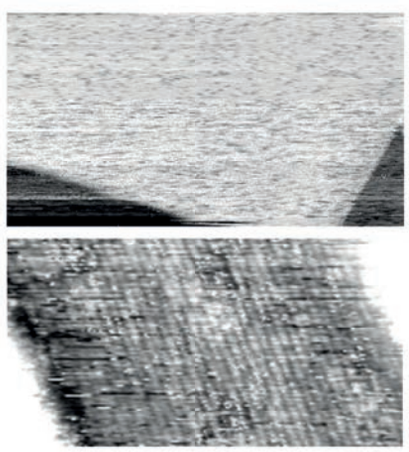


Figure 1. *STM images of an Ag single crystal surface, recorded in a reaction gas mixture of 0.5 mbar of ethylene and 0.5 mbar of oxygen at 470 K. Under these conditions catalytic ethylene epoxide formation is detected. Top image 490 Å x 260 Å, bottom image 250 Å x 130 Å.*

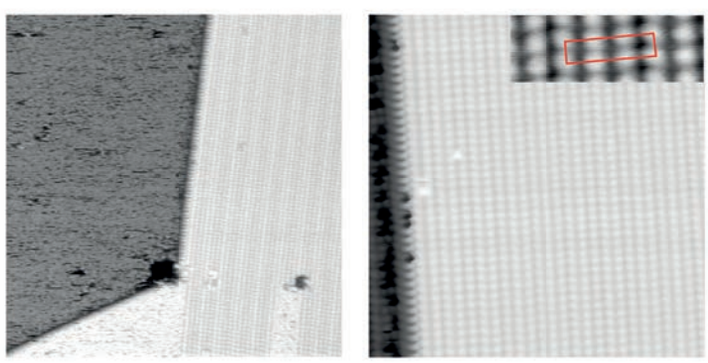


Figure 2. *STM images of an Ag single crystal surface in vacuum, showing the two catalytically active surface phases. Left image 480 Å x 480 Å, right image 200 Å x 200 Å.*

S. Böcklein, S. Günther, J. Wintterlin: *High-pressure scanning tunneling microscopy of a silver surface during catalytic formation of ethylene oxide, Angew. Chem. 125, 5623 (2013);* Angew. Chem. Int. Ed. 52, 5518 (2013).

CALMODULIN REGULATES DIMERISATION, MOTILITY AND LIPID BINDING OF LEISHMANIA MYOSIN XXI

Prof. Claudia Veigel (LMU Munich, Faculty of Medicine) *www.cell.physiol.med.uni-muenchen.de/research_gr/veigel*

Myosin-XXI is the only myosin expressed in *Leishmania* parasites. Although it is assumed that it performs a variety of motile functions, the motor's oligsomerisation states, cargo-binding and motility are unknown. Here we show that binding of a single calmodulin causes the motor to adopt a monomeric state and to move actin filaments. In the absence of calmodulin, non-motile dimers were formed that crosslinked actin filaments. Unexpectedly, structural analysis revealed that the dimerisation domains include the calmodulin-binding neck region, essential for the generation of force and movement in myosins. Furthermore monomeric myosin-XXI bound to mixed liposomes, while the dimers did not. Lipid binding sections overlapped with the dimerisation domains, but also included a phox-homology (PX) domain in the converter region. We propose a novel mechanism of myosin regulation, where dimerisation, motility and lipid binding are regulated by calmodulin. While myosin-XXI dimers might act as non-motile actin crosslinkers, the calmodulin-binding monomers might transport lipid cargo in the parasite.

C. Batters, H. Ellrich, C. Helbig, K.A. Woodall, C. Hundschell, D. Brack and C. Veigel: *Calmodulin regulates dimerisation, motility and lipid binding of Leishmania myosin XXI;* PNAS, 111, E227-236 (2014) Epub 2013 Dec 30.

IMPROVED GENE TRANSFER BY SEQUENCE-DEFINED OLIGOMERS WITH OPTIMIZED PH BUFFER CAPACITY

Prof. Christoph Bräuchle (LMU Munich, Chemistry Department) *www.cup.uni-muenchen.de/pc/braeuchle*
Prof. Ernst Wagner (LMU Munich, Pharmacy Department) *www.cup.uni-muenchen.de/pb/aks/ewagner*

In the gene transfer process, polymer-based pDNA complexes are taken up into cells by endocytosis and thus are exposed to a varying range of different pH values (Figure 1). Efficient carriers utilize such pH gradients to change their properties in a dynamic fashion advantageous for the delivery process. Opposing requirements are: on the one hand, polymer basicity providing positive charges for stabilization of nucleic acid (NA) complexes at extracellular neutral pH; on the other hand, lower basicity with pK values in the endosomal acidic range providing proton sponge character. Endosomal protonation correlates with endosomal lipid membrane disruption and release of complexes into the cytosol. Tuning the 'proton sponge' profile was now found to further optimize gene carriers. In particular, sequence-defined oligomers combining oligoamino acids (Stp and Sph) with histidines (Figure 2) display improved buffer capacity, increased endosomolytic properties (Figure 3) and greatly enhanced gene transfer activity of pDNA complexes both in vitro and in vivo in a mouse tumor model (see ref. Lächelt et al).

U. Lächelt, P. Kos, F.M. Mickler, A. Herrmann, E.E. Salcher, W. Rödl, N. Badgujar, C. Bräuchle, E. Wagner: *Fine-tuning of proton sponges by precise diaminoethanes and histidines in pDNA polyplexes;* Nanomedicine NBM 10, 35–44 (2014). Epub 2013 Jul 24.

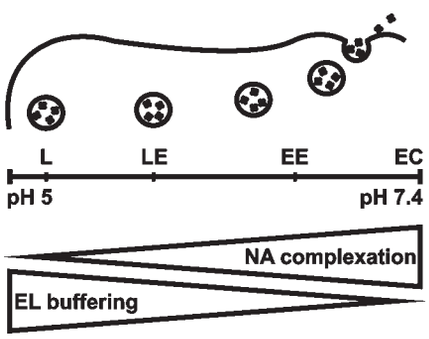


Figure 1. *For maximum intracellular delivery, a therapeutic polyanionic nucleic acid (NA) has to be complexed with cationic transfection agents. By natural acidification within endolysosomes (EL), the pH alters from pH7.4 in the extracellular space (EC) gradually from early endosomes (EE) to pH5 in late endosomes (LE) and lysosomes (L). Oligomer protonation capacity in this acidic area is required for EL lipid membrane disruption and escape of NA complexes to the cytosol.*

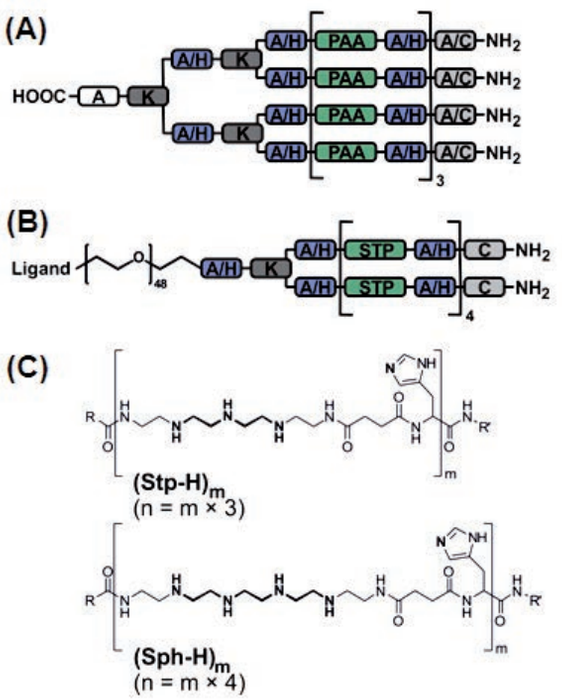


Figure 2. *Oligo(ethanamino) amides with (A) four-arm topology or (B) targeting ligand-containing PEGylated two-arm topology. (C) Chemical structures of different PAA-H. PAA represents the used oligoamino acids Stp or Sph. A, K, H and C stand for corresponding α-amino acids in one-letter-code. n indicates number of protonatable ethanamino nitrogens.*

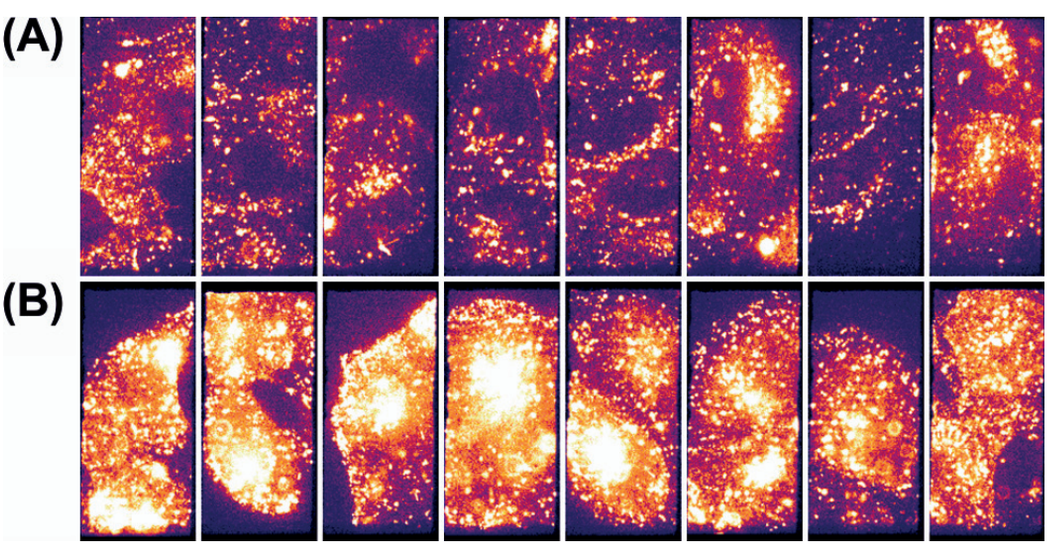
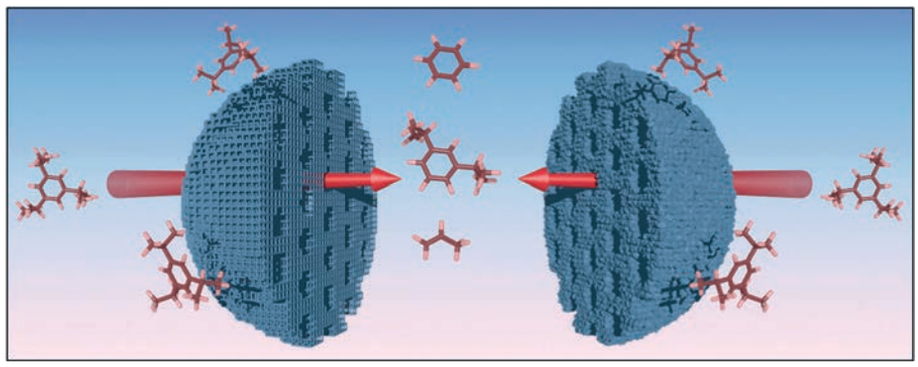


Figure 3. *Intracellular cytosolic calcein release assay in DU145 cells transfected with pDNA complexes without (A) or with (B) histidines in the oligomer sequence.*

NANOZEOLITES

Prof. Thomas Bein (LMU Munich, Chemistry Department) *http://bein.cup.uni-muenchen.de*

Zeolites are crystalline materials containing precisely defined pores with diameters matching the size of small molecules. They play an important role in chemical processing due to their size- and shape-selective catalytic properties as well as being valuable adsorbers, separators and ion-exchangers. However, despite being extremely beneficial their micropores impose restrictions on the mass transport of bulkier reactants. Numerous efforts have lately been undertaken to boost the catalytic power of zeolites by introducing secondary diffusion pathways on the mesoscale into the zeolite bodies thus creating a new class of material described as hierarchical zeolites. The authors have written a tutorial review that gives a general overview of the diverse strategies on how to implement a secondary pore system in zeolites that boosts the catalytic power of zeolites and extends their applications to new areas.



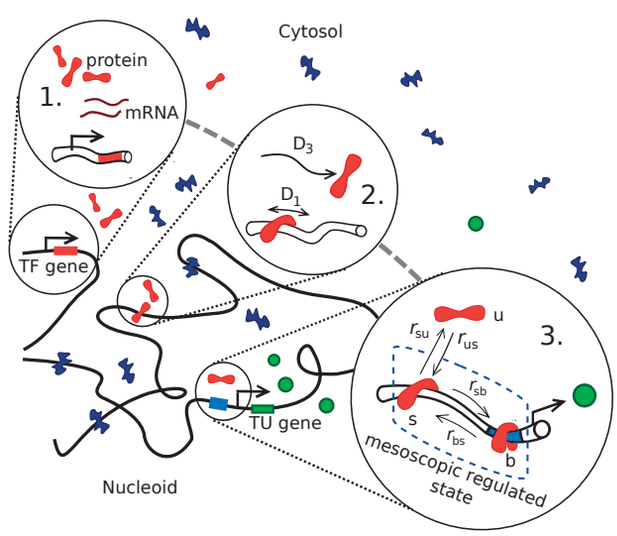
Schematic representation of a secondary pore system to facilitate the access to and diffusion of bulky molecules within microporous zeolites. These mesopores can be constructed as intracrystalline voids within zeolite single crystals (left) or may be formed as intercrystalline pores in nanozeolite aggregates (right).

K. Moeller, T. Bein: *Mesoporosity - a new dimension for zeolites;* Chemical Society Reviews 42(9), 3689-3707 (2013).

GENE REGULATION IN LIVING CELLS: AN EXTENDED FACILITATED DIFFUSION MODEL

Prof. Ralf Metzler (University of Potsdam, Institute of Physics and Astronomy and Physics Department, Tampere University of Technology, Finland) *www.agnld.uni-potsdam.de/~metz/rmetzler.html*

We consider the thermally driven, random search of certain DNA-binding proteins, so-called transcription factors, for their specific target site on the DNA. After binding, they repress or activate the transcription of a gene. Under dilute in vitro conditions such transcription factors were shown to rapidly locate their target sequence on DNA by using the Berg-von Hippel facilitated diffusion mechanism. However, whether this strategy of alternating between three-dimensional bulk diffusion and one-dimensional sliding along the DNA contour is still beneficial in the crowded interior of living biological cells is highly disputed. In this project we use a simple model for the genome in a bacteria cell and present a semi-analytical model for the in vivo target search of transcription factors within the facilitated diffusion framework. Without having to resort to extensive simulations we determine the mean search time of a lac repressor in a living E. coli cell by including parameters deduced from experimental measurements. The results agree very well with experimental findings, and thus the facilitated diffusion picture emerges as a quantitative approach to gene regulation in living bacteria cells. Furthermore we see that the search time is not very sensitive to the parameters characterising the DNA configuration and that the cell seems to operate very close to optimal conditions for target localisation. Local searches as implied by the colocalisation mechanism are only found to mildly accelerate the mean search time within our model. In a related work we demonstrate that even in the confines of a bacteria cell the spatial distance between two interacting genes plays an important role in the accuracy of the gene control.



Three stochastic phases in transcriptional regulation: Transcription factor (TF) production. *TFs perform facilitated diffusion in the nucleoid (inside the dashed line) containing the DNA. Diffusion is purely 3D in the cytosol outside the nucleoid. TFs find the operator of the transcription unit (TU) gene by sliding along the DNA. The irregularly shaped blue objects depict other molecules which affect the facilitated diffusion and binding affinity of the TF.*

M. Bauer and R. Metzler: *In vivo facilitated diffusion model;* PLoS ONE 8, e53956 (2013).

O. Pulkkinen and R. Metzler: *Distance matters: the impact of gene proximity in bacterial gene regulation;* Phys. Rev. Lett. 110, 198101 (2013).

THE MICROSCOPIC ORIGIN OF THE 0.7-ANOMALY IN QUANTUM POINT CONTACTS

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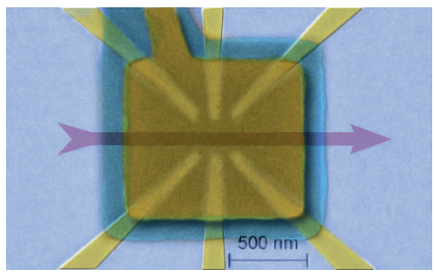
PD Dr. Stefan Ludwig (LMU Munich, Faculty of Physics) *www.nano.physik.uni-muenchen.de/quantumtransport*

The miniaturization of the electronic building blocks in modern integrated circuits continues apace – indeed it remains a major driver of technological progress. But component size has now been reduced to dimensions at which quantum mechanical effects become significant. A better understanding of the relevant quantum phenomena at this scale could lead to the development of a new generation of electrical microcomponents, still smaller and even more efficient than those currently in use. One of the most prominent of these phenomena concerns the transport of electrons through a short, one-dimensional constriction known as a quantum point contact. In contrast to the situation at macroscopic scales, the electrical conductance through such a contact is quantized. When the effective width of the contact is decreased by tuning a gate voltage, its conductance falls in a stepwise fashion, and the size of each step is equal to the fundamental quantum of conductance. However, quantum point contacts also display a subtle many-body effect within the last conductance step, which results in what is called the 0.7 anomaly. When the conductance reaches a value of 0.7 of the quantum of conductance, it shows an unexpected and significant reduction - here the electrons apparently encounter an extra hurdle which makes it more difficult for them to traverse the contact. This effect has been investigated extensively for the past 15 years or so, but its underlying cause at the microscopic level has remained unknown. The current article has finally solved this long-standing riddle thanks to a clever combination of experimental measurements and numerical modeling. The basis for the effect is actually fairly obvious. As the constriction gets progressively narrower, the electrons within the bottleneck move more slowly. Shortly before the constriction becomes so narrow that electrons cannot pass at all, they become congested, and thus inhibit the mobility of other electrons in the vicinity. Anybody who has been jostled in a crowd trying to pass through a narrow entrance will have experienced an analogous effect. Achieving a detailed theoretical description of the resulting electronic traffic jam was a great challenge, however, which required close cooperation between theorists and experimentalists.



Gate layout of the nanoscale device. Shown is the surface of a GaAs/AlGaAs heterostructure with a high mobility two-dimensional electron system 100 nm beneath the surface. The yellow colored regions are gold gates on the surface including six narrow "side" gates and one large "top" gate. The latter is semitransparent and electrically isolated from the other gates by a thin insulating layer (PMMA, dark shadow). The gates are used to define and finetune a narrow constriction, the quantum point contact, connecting two two-dimensional electrical contacts.

F. Bauer, J. Heyder, E. Schubert, D. Borowsky, D. Taubert, B. Bruognolo, D. Schuh, W. Wegscheider, J. von Delft, and S. Ludwig: *The Microscopic Origin of the 0.7-Anomaly in Quantum Point Contacts;* Nature 501, 73 (2013).

NANOSCALE FRICTION

Prof. Thorsten Hugel (TU Munich, Department of Physics) *http://bio.ph.tum.de/home/e22-prof-dr-hugel/hugel-home.html*
Prof. Alexander Holleitner (TU Munich, Walter Schottky Institute and Department of Physics) *www.nanoptronics.de*

Friction is an omnipresent but often annoying physical phenomenon: It causes wear and energy loss in machines as well as in our joints. In search of low-friction components for ever smaller components, a team of physicists led by the professors Thorsten Hugel and Alexander Holleitner now discovered a previously unknown type of friction that they call "desorption stick." The researchers examined how and why single polymer molecules in various solvents slide over or stick to certain surfaces. Their goal was to understand the basic laws of physics at the molecular scale in order to develop targeted anti-friction surfaces and suitable lubricants. For their studies the scientists attached the end of a polymer molecule to the nanometer-fine tip of a highly sensitive atomic force microscope (AFM). While they pulled the polymer molecule over test surfaces, the AFM measured the resulting forces, from which the researchers could directly deduce the behavior of the polymer coil. Besides the two expected friction mechanisms such as sticking and sliding the researchers detected a third one for several combinations of polymer, solvent and surface. Although the polymer sticks to the surface, the polymer strand can be pulled from its coiled conformation into the surrounding solution without significant force to be exerted. The cause is probably a very low internal friction within the polymer coil. Surprisingly, desorption stick depends neither significantly on the speed of movement nor on the support surface or adhesive strength of the polymer. Instead, the chemical nature of the surface and the quality of the solvent are decisive. For example, hydrophobic polystyrene exhibits pure sliding behavior when dissolved in chloroform, while it shows desorption stick in water. This understanding of single-molecule friction opens up new ways to develop new surfaces with specific friction properties.

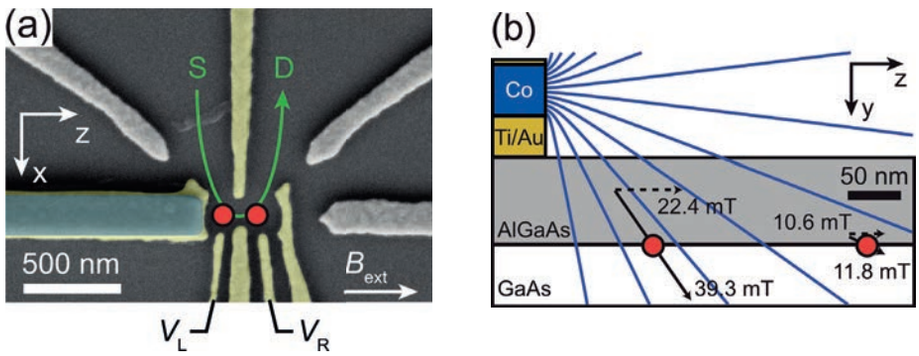
B. N. Balzer, M. Gallei, M. Hauf, M. Stallhofer, L. Wiegleb, A. Holleitner, M. Rehahn, T. Hugel: *Nanoscale Friction Mechanisms at Solid–Liquid Interfaces;* Angew. Chem. Int. Ed. 52(25) 6541 (2013).

B. N. Balzer, M. Gallei, M. Hauf, M. Stallhofer, L. Wiegleb, A. Holleitner, M. Rehahn, T. Hugel: *Reibungsmechanismen auf der Nanoskala an Fest-flüssig-Grenzflächen;* Angew. Chem. 125 (2013).

LARGE NUCLEAR SPIN POLARIZATION IN GATE-DEFINED QUANTUM DOTS USING A SINGLE-DOMAIN NANOMAGNET

PD Dr. Stefan Ludwig (LMU Munich, Faculty of Physics) *www.nano.physik.uni-muenchen.de/quantumtransport*

Semiconductor based quantum dot (QD) circuits are intensively studied as model systems for spin-based quantum information. Nuclear spins are important as they limit spin qubit coherence times, if uncontrolled, but promise applications as quantum memory, once under control. One of the most promising material systems is GaAs/AlGaAs heterostructures as these can be engineered to harbor the most perfect two-dimensional electron systems (2DES) available. In such a 2DES, typically 100 nm beneath the crystal surface, QDs can be created electrostatically by means of applying negative voltages to nanoscale metal gates on the surface. Our double QD gate layout is shown in the attached figure. In addition to gold gates (yellow) the sample is equipped with a long Cobalt rod (blue) which is a single domain nanomagnet. Originating an inhomogeneous magnetic field it helps to manipulate electron and nuclear spins in the double QD. This can be done, for instance, by simply driving current through the double QD if it is tuned such that tunneling of electrons requires their spins to flip. Via the hyperfine interaction electron spin flips can cause nuclear spins to flip, where each electron confined in a QD couples to about 100.000 nuclei. The present article demonstrates very efficient nuclear spin manipulation in QDs based on a dc current, the inhomogeneous field of a nanomagnet and a broken symmetry in the electron spin (up versus down) flip rates. In the present article a nuclear spin polarization of about 50% has been reached, unrivaled in gate defined QDs.



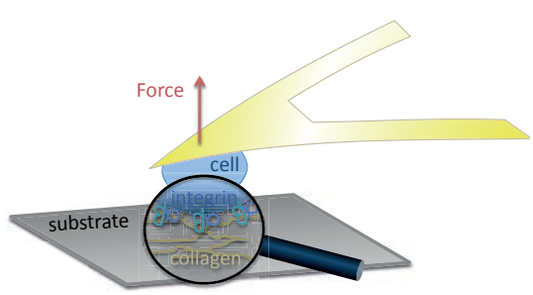
(a) Gate layout of the double quantum dot. Shown is the surface of a GaAs/AlGaAs heterostructure which contains a 2DES 85 nm below. The yellow colored gates are used to define the double QD with potential minima near the red circles, the blue region is half of the Cobalt nanomagnet. The green arrow indicates the steady state current flowing through the device from the source (S) to drain (D) contact. (b) Simulation of the nanomagnets magnetic field. The two red circles indicate the approximate position of the two QDs. The simulated field has been verified by experiments.

G. Petersen, E. A. Hoffmann, D. Schuh, W. Wegscheider, G. Giedke, and S. Ludwig: *Large nuclear spin polarization in gate-defined quantum dots using a single-domain nanomagnet;* Phys. Rev. Lett. 110, 177602 (2013).

QUANTIFYING CELL ADHESION AND CELL MECHANICS FOR CLINICAL RESEARCH USING SINGLE CELL FORCE SPECTROSCOPY

Dr. Martin Benoit (LMU Munich, Faculty of Physics) *www.biophysik.physik.uni-muenchen.de/personen/group_leader/benoit_martin*

Forces play an important role in cell adhesion and are directly measured at the level of individual cell adhesion molecules by AFM. Integrins are very important cell adhesion molecules tuned by the cell in their adhesion strength in order facilitate cell migration or cell homing. From a clinical point of view they prominently contribute in tumor metastasis and thus detailed information about integrin function is of interest for therapeutic reason. The adhesion strength of metastasizing prostate carcinoma cells is for two carcinoma model cell lines "LNCaP" (lymph node-specific) and "PC3"(bone marrow-specific). A PC3 cell immobilized to a force sensor and probed on bone marrow-derived mesenchymal stem cells showed stronger adhesion than LNCaP cells. The mechanical pattern of this adhesion was characterized for both prostate cancer cell lines and compared to a substrate consisting of pure collagen type I. PC3 cells dissipated more energy during the forced de-adhesion AFM experiments and showed significantly more adhesive and stronger bonds compared to LNCaP cells. The characteristic signatures of the detachment force traces revealed that, in contrast to the LNCaP cells, PC3 cells seem to utilize filopodia in addition to establish adhesive bonds. The study clearly demonstrates that PC3 cells have a superior adhesive affinity to bone marrow mesenchymal stem cells, compared to LNCaP. Quantitative PCR on both prostate carcinoma cell lines revealed the 8-fold stronger expression of the two collagen binding integrins, α1β1 and α2β1, in PC3 cells. Further understanding of the exact mechanisms behind this phenomenon might lead to optimized therapeutic applications targeting the metastatic behavior of certain prostate cancer cells towards bone tissue.



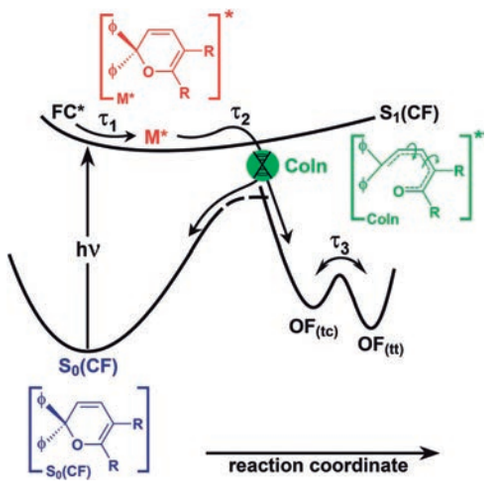
A Prostate carcinoma cell immobilized to an AFM force sensor releases its integrin bonds to a collagen substrate while the sensor is moved upwards and the required force is measured.

E. Sarıısık, D. Docheva, D. Padula, C. Popov, J. Opfer, M. Schieker, H. Clausen-Schaumann, M. Benoit: *Probing the interaction forces of prostate cancer cells with collagen I and bone marrow derived stem cells on the single cell level;* PLoS One 8(3), e57706 (2013).
J. Friedrichs, K.R. Legate, R. Schubert, M. Bharadwaj, C. Werner, D.J. Müller, M. Benoit: *A practical guide to quantify cell adhesion using single-cell force spectroscopy;* Methods 60(2),169-78 (2013).

MOLECULAR MECHANISMS OF FUNCTIONAL MATERIALS USED IN PHOTOTROPIC GLASSES

Prof. Thorben Cordes (University of Groningen, Faculty of Mathematics and Natural Sciences) *www.molecular-microscopy.nl*

Due to their promising applications in both the material and life sciences, the interest in photoswitchable compounds has notably increased over the past few decades. Simple chemical transformations, such as pericyclic reactions or Z/E-isomerizations, form the functional basis for functional materials based on such compounds. Despite their importance many of the underlying molecular mechanisms are not yet fully understood. In this project we investigate the photochromic ring-opening reaction of 2,2-diphenyl-5,6-benzo(2H)-chromene (DPCC). In particular, we study the uncertainties and contradictions in various published reaction models using a combination of transient absorption and fluorescence spectroscopy with femtosecond time resolution. We propose a simplified reaction scheme which is in good agreement with theoretical studies. Here, photoexcitation populates a Franck–Condon state, whose fast vibrational wave packet motion, vibrational relaxation, bond-alternation and/or solvent rearrangement processes occur on the sub-picosecond timescale. Our data suggest that the resulting excited state minimum with picoseconds lifetime still features structural characteristics of the closed form. Subsequently, the ring-opened photoproducts are formed in a concerted step from the excited state. The velocity of the photoreaction hence only depends on the time that the molecule needs to reach the transition region between the ground and excited states where the crucial bond breakage occurs. The presented results have implications for the understanding of chromene photochemistry, reaction mechanisms of compounds with related photochemistry and ultimately for the design of photochromic materials with custom-made properties.



Proposed reaction model of chromene DPBC after excitation by UV light. In a first step relaxation from the Franck–Condon region (FC) into an excited state minimum (M*) occurs (τ_1), which is followed by a transition through a conical intersection (CoIn, τ_2). Here branching of the population into product (80%) and educt (20%) occurs in ACN; the branching ratio depends on solvent and excitation conditions. Bond cleavage between oxygen and spiro-carbon produces both open form isomers OF. The OF(tc) isomer in trans–cis geometry can transform into the trans–trans isomer OF(tt), by rotation around the C(4)–C(5) double bond (thermal equilibration, τ_3).*

T. T. Herzog, G. Ryseck, E. Ploetz, T. Cordes: *The photochemical ring opening reaction of chromene as seen by transient absorption and fluorescence spectroscopy;* Photochemical & Photobiological Sciences 12, 1202-1209 (2013).

ESCALATION OF POLYMERIZATION IN A THERMAL GRADIENT

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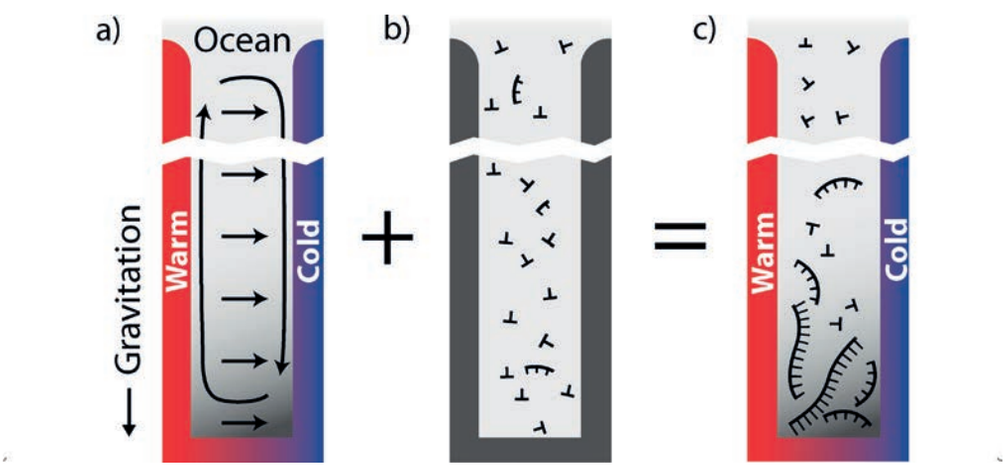
Prof. Ulrich Gerland (LMU Munich, Faculty of Physics) *www.theorie.physik.uni-muenchen.de/lsfrey/members/group_leaders/ulrich_gerland*

In a collaboration with Ulrich Gerland, the Braun lab could provide combined theoretical and experimental evidence that thermal trapping can enhance the polymerization of prebiotic monomers. For the emergence of early life, the formation of biopolymers such as RNA is essential. However, the addition of nucleotide monomers to existing oligonucleotides requires millimolar concentrations. Even in such optimistic settings, no polymerization of RNA longer than about 20 bases could be demonstrated. The gradient accumulates monomers by thermophoresis and convection while retaining longer polymers exponentially better. Polymerization and accumulation become mutually self-enhancing and result in a hyperexponential escalation of polymer length. The model predicts that a pore length of 5 cm and a temperature difference of 10 K suffice to polymerize 200-mers of RNA in micromolar concentrations.



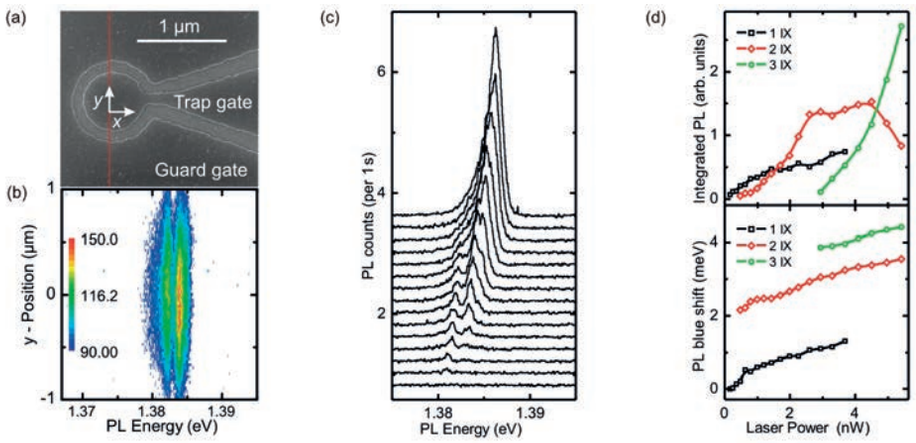
Polymerization in a thermal gradient. The combination of thermal trapping (thermophoresis and thermal convection) and a polymerization reaction leads to exceedingly long oligonucleotides. This finding potentially solves a central question of the origin of life: how could the first information bearing polymers have been formed.

Christof B. Mast, Severin Schink, Ulrich Gerland and Dieter Braun: *Escalation of Polymerization in a Thermal Gradient;* PNAS 110, 8030-8035 (2013).

INTERACTION OF DIPOLAR EXCITONS CONFINED IN ELECTROSTATIC TRAPS

Prof. Alexander Holleitner (TU Munich, Walter Schottky Institute and Department of Physics) *www.nanoptronics.de*
Prof. Jörg P. Kotthaus (LMU Munich, Faculty of Physics) *www.nano.physik.uni-muenchen.de*

The photoluminescence of spatially indirect dipolar excitons, generated in an InGaAs-Double Quantum Well (DQW) and confined to electrostatically created and voltage-tunable traps, is explored for interaction phenomena at low temperatures. In a 3He refrigerator with a base temperature below 250mK two fiber-coupled confocal microscopes are employed to spatially separate the optical exciton generation by a few micrometers from the gate area beneath which the dipolar excitons are trapped and studied via photoluminescence (PL) spectroscopy. This enables an efficient cooldown of the dipolar exciton ensemble in the trap to a regime in which the thermal de Broglie wavelength of the excitons becomes comparable to their mean separation. The diameter of the smallest trapping gates is several hundred nanometers (a). In these strongly confining traps the transition from an ensemble of many excitons down to a single, electrostatically trapped dipolar exciton can be studied at low temperatures. In the few exciton regime discrete emission lines are observed and identified as resulting from a single exciton, two excitons and three excitons, respectively, confined to the trap and interacting by strong dipolar repulsion (b-d). At higher exciton occupation the discrete lines merge into a characteristic asymmetric line shape reflecting the dipolar interaction within the excitonic ensemble. In addition, Mahan excitons, consisting of individual holes interacting with a degenerate two-dimensional electron systems, are found to exhibit strong quantum Hall effect signatures in high magnetic fields. When formed around the perimeter of a trap containing neutral excitons their specific, quantum-Hall-effect-induced screening action influences the energy of the trapped dipolar excitons.



Photoluminescence (PL) of dipolar excitons laterally confined in a tight electrostatic trap fabricated on an InGaAs double quantum well at T = 250 mK (a) Scanning electron micrograph of the gate geometry (b) Confocal image of the PL intensity (color coded) vs. energy and y-position with the trap filled with 2 excitons (c) PL with increasing trap occupation induced by the pump laser power rising from 55pW to 10nW (d) Integrated PL intensity (top) and blue shift of the PL energy vs. pump laser power (after Schinner et al., Phys. Rev. Lett. 110, 127403 (2013))

G. J. Schinner, J. Repp, E. Schubert, A. K. Rai, D. Reuter, A.D. Wieck, A. O. Govorov, A. W. Holleitner, and J. P. Kotthaus: *Confinement and Interaction of Single Indirect Excitons in a Voltage-Controlled Trap Formed Inside Double InGaAs Quantum Wells;* Phys. Rev. Lett. 110 127403 (2013).

G.J. Schinner, J. Repp, E. Schubert, A.K. Rai, D. Reuter, A.D. Wieck, A.O. Govorov, A.W. Holleitner, and J.P Kotthaus: *Many-body correlations of electrostatically trapped dipolar excitons;* Phys. Rev. B. 87 205302 (2013).

G. J. Schinner, J. Repp, K. Kowalik-Seidl, E. Schubert, M. P. Stallhofer, A. K. Rai, D. Reuter, A.D. Wieck, A. O. Govorov, A. W. Holleitner, and J. P. Kotthaus: *Quantum Hall signatures of dipolar Mahan excitons;* Phys. Rev. B 87, 041303(R) (2013).

PROGRESS IN MICROSCALE THERMOPHORESIS (MST)

Prof. Dieter Braun (LMU Munich, Faculty of Physics) *www.biosystems.physik.uni-muenchen.de*
Dr. Stefan Duhr & Dr. Philipp Baaske (NanoTemper Technologies GmbH) *www.nanotemper-technologies.com*

Microscale Thermophoresis (MST) allows for quantitative analysis of protein interactions in free solutions and with low sample consumption. The interaction of small molecules and peptides with proteins is, despite the high molecular weight ratio, readily accessible via MST. Measuring is even possible in complex bioliquids like cell lysate and thus under close to in vivo conditions and without sample purification. Binding modes that are quantifiable via MST include dimerization, cooperativity and competition.

A Review, made in a collaboration between Nanotemper and several academic labs, shows the progress and possibilities of the technique.

S.A.I. Seidel, P.M. Dijkman, W.A. Lea, G. van den Bogaart, M. Jerabek-Willemsen, A. Lazic, J.S. Joseph, P. Srinivasan, P. Baaske, A. Simeonov, I. Katritch, F.A. Melo, J.E. Ladbury, G. Schreiber, A. Watts, D. Braun, S. Duhr: *Microscale thermophoresis quantifies biomolecular interactions under previously challenging conditions;* Methods 59, 301–315 (2013).

EXCITONS IN CARBON NANOTUBES

Prof. Alexander Högele (LMU Munich, Faculty of Physics) *www.nano.physik.uni-muenchen.de/nanophotonics*

The luminescence of single semiconducting carbon nanotubes (CNTs) is typically limited by a low quantum yield, rapid exciton decoherence at nonradiative quenching sites as well as by spectral wandering. These properties significantly impede the realization of CNT-based optical and quantum-optical devices. In our work we show that such limitations can be overcome by localized excitons in freely suspended CNTs. For this purpose we grew CNTs by chemical vapor deposition (CVD) on a perforated membrane. In contrast to conventional and commercially available CNTs our CVD-grown nanotubes exhibited remarkable emission properties at cryogenic temperatures: the photoluminescence was spectrally narrow (limited by our spectrometer resolution of 40 μeV), free from spectral wandering and blinking, and featured one order of magnitude longer decay times in the nanoseconds range. These spectral features, accompanied by strong antibunching in the photoluminescence emission statistics, render localized excitons in suspended CNTs ideal candidates for quantum-optical studies.

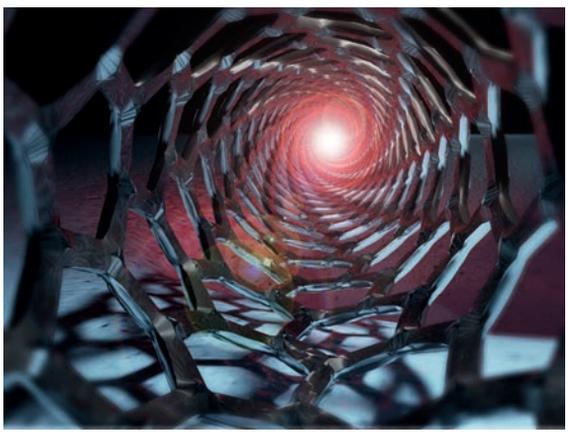


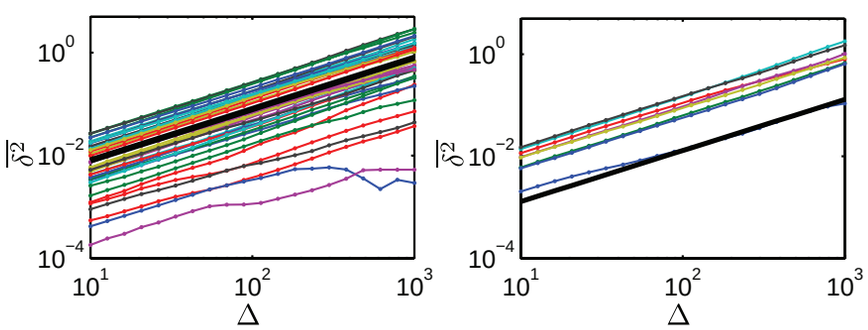
Image: Christoph Hohmann / NIM.

M.S. Hofmann, J.T. Glückert, J. Noé, C. Bourjau, R. Dehmel, and A. Högele: *Bright, long-lived and coherent excitons in carbon nanotube quantum dots;* Nature Nanotechnology 8, 502-505 (2013).

AGEING AND WEAK ERGODICITY BREAKING IN ANOMALOUS DIFFUSION

Prof. Ralf Metzler (University of Potsdam, Institute of Physics and Astronomy and Physics Department, Tampere University of Technology, Finland) *www.agnld.uni-potsdam.de/~metz/rmetzler.html*

A growing number of experiments report systematic differences between ensemble and time averages of physical observables of the same anomalous diffusion process. Concurrently, results for the time averaged mean squared displacement from different realisations in the same system show a pronounced scatter of amplitudes, and even long time measurements are not reproducible. These features of the so-called weak ergodicity breaking are a fundamental physical property of a range of anomalous diffusion processes. Examples include the motion of granules in the cytoplasm or of protein channels in the plasma membranes of living biological cells as well as the blinking dynamics of quantum dots. Intimately associated with this seemingly strange behaviour is the phenomenon of ageing, the explicit dependence of a measured quantity on the age of the system from its original preparation to the start of the measurement. We showed in the framework of stochastic processes with scale-free waiting waiting times that time averaged observables indeed represent a much better basis for the physical analysis of an aged system than the---differently behaved---ensemble averages. Moreover we found that after an ageing period elapses, an ensemble of diffusing particles splits up into a completely immobile fraction and another fraction with varying mobility. This population splitting is another prominent feature of anomalous diffusion. We also showed that weak ergodicity breaking and ageing occur in a number of different, seemingly simpler systems, such as for diffusion processes with a space-dependent diffusion coefficient.



Time average mean squared displacement for individual free trajectories of a scale-free waiting time process for non-aged (left) and aged (right) process, as function of the lag time. In each case 40 trajectories were simulated. In the aged case most of them are completely immobile and thus do not show in the plot. The black lines correspond to the theoretical average over many trajectories. See Schulz et al, Phys Rev. Lett 110, 020602 (2013) for details.

J. Schulz, E. Barkai, and R. Metzler: *Ageing effects in single particle trajectory averages;* Phys. Rev. Lett. 110, 020602 (2013).

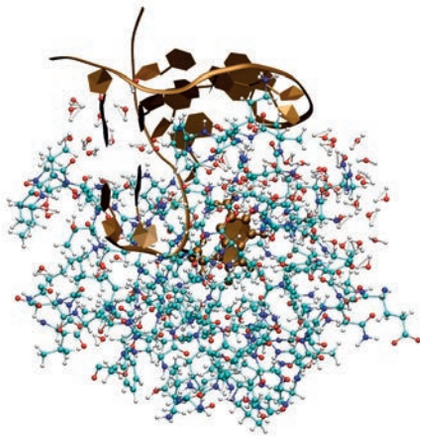
M. A. Lomholt, L. Lizana, R. Metzler, and T. Ambjörnsson: *Microscopic origin of the logarithmic time evolution in complex systems;* Phys. Rev. Lett. 110, 208301 (2013).

A. G. Cherstvy, A. V. Chechkin, and R. Metzler: *Anomalous diffusion and ergodicity breaking in heterogeneous diffusion processes;* New J. Phys. 15, 083039 (2013).

QUANTUM CHEMICAL METHODS FOR STUDYING LARGE BIOCHEMICAL SYSTEMS

Prof. Christian Ochsenfeld (LMU Munich, Chemistry Department) *www.cup.uni-muenchen.de/pc/ochsenfeld*

Quantum-chemical calculations can often provide important insights into complex molecular systems which are experimentally difficult or even not accessible such as complex reaction mechanisms (e.g., short-lived intermediates) or intermolecular interactions. Despite tremendous advancements in the development of efficient quantum-chemical methods for large molecular systems, the accurate treatment of electron correlation effects, which are essential for describing London dispersion (or van der Waals) interactions, is still a major challenge for system as large as those required for studying, e.g., enzymatic biochemical reactions. In the last years, the Ochsenfeld group has developed efficient methods for the computation of the second order energy correction in Møller-Plesset perturbation theory (MP2) which is the cheapest quantum chemical approach that provides a reasonable description of dispersion effects. These methods are based on a local description of correlation effects usually in terms of contributions of individual atomic orbitals. While there is a huge number of such contributions, only a relatively small amount of these actually signficantly influence the final result. Therefore, the Ochsenfeld group developed techniques for the preselection of significant contributions based on efficient estimates for electron repulsion integrals. In recent work by Maurer et al., new and improved estimates have been presented that are based on a multipole-based analysis of the electron integrals and that provide much tighter estimates than previous attempts. The important feature of these estimates is the description of the integral decay with increasing separation of the two charge distributions involved that ultimately allows to restrict the calculation to an amount of integral contributions which scales linearly with the size of the molecular system. In combination with efficient parallelization techniques, this opens the way for calculating large biochemical systems at the scaled opposite-spin MP2 level using distance-dependent integral estimates as demonstrated for a cutout of a DNA-repair complex with more than 2000 atoms.



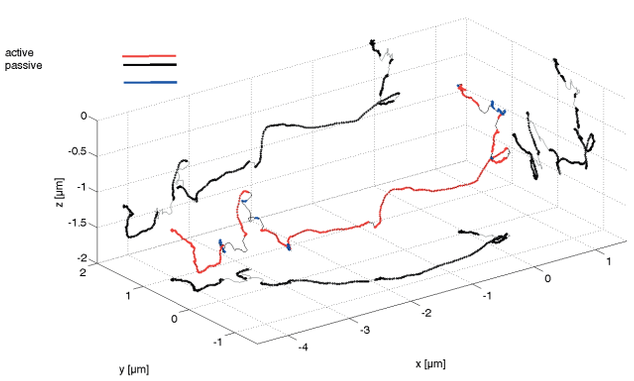
*Cutout of a DNA double strand with an 8-oxoguanine lesion in complex with the DNA repair enzyme MutM. The cutout comprises 2025 atoms and was calculated using the atomic orbital-based scaled opposite-spin (SOS-AO-)MP2 method in a 6-31G** basis.*

S.A. Maurer, D. S. Lambrecht, J. Kussmann, C. Ochsenfeld: *Efficient distance-including integral screening in linear-scaling Møller-Plesset perturbation theory;* J. Chem. Phys. 138, 014101 (2013).

NEWS FROM THE THIRD DIMENSION

Prof. Don C. Lamb (LMU Munich, Chemistry Department) *www.cup.uni-muenchen.de/pc/lamb*
Prof. Doris Heinrich (University of Leiden, Institute of Physics) *www.physics.leidenuniv.nl/hl-home*

Single particle tracking (SPT) inside cells has the capability to reveal quantitative mechanistic information on processes which are relevant for the health and function of the cell. Although three dimensional tracking methods are being developed, most tracking experiments have done in two dimensions. However, cells are 3 dimensional and an anisotropic environment. To evaluate the differences between a two and a three dimensional SPT experiment, the group of Prof. Lamb performed three dimensional SPT experiments in cell lines with different morphologies (Polyplex uptake in HuH-7 and dictyostelium discoideum) on a home build 3D real time orbital tracking microscope [1-2]. The trajectories of these experiments were then analyzed by the group of Prof. Heinrich with their TRAnSpORT algorithm using the full three dimensional data set and a two dimensional projection onto the xy plane [3]. For isotropic systems or purely two dimensional movements, it is accurate and sufficient to use tracking in two dimensions. However, in real life the comparison of the two cell lines revealed that especially the diffusion coefficient is highly biased by a two dimensional experiment, revealing that intracellular diffusion is not isotropic. The analysis of other movement parameters, for example the number of active phases and their velocities, revealed that the differences between two and three dimensions depend on the cell morphology. Although three dimensional SPT experiments are technically harder to accomplish, they are necessary and crucial for the correct interpretation of the processes inside cells.



A three-dimensional representation of the polyplex motion in the cell and associated projections of the trajectories in the x–y, x–z and y–z planes. The phases of active transport are shown in red and the diffusive phases are shown in blue. As seen in the projections, the particle moves significantly in the z direction.

[1] A. Dupont and D.C. Lamb: *Nanoscale three-dimensional single-particle tracking;* Nanoscale 3, 4532–41 (2011).
[2] Y. Katayama, O. Burkacky, M. Meyer, C. Bräuchle, E. Gratton and D.C. Lamb: *Real-time nanomicroscopy via three-dimensional single-particle tracking;* ChemPhysChem., 10, 2458–64, 2009.
[3] D. Arcizet D, B. Meier, E. Sackmann, J.O. Rädler and D. Heinrich: *Temporal analysis of active and passive transport in living cells;* Phys. Rev. Lett. 101, 248103, (2008).

PERIODIC MESOPOROUS ORGANOSILICA

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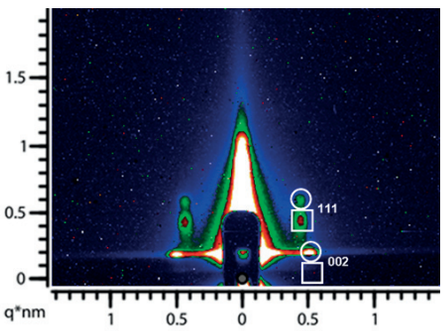
Prof. Dirk Trauner (LMU Munich, Chemistry Department) *www.cup.uni-muenchen.de/oc/trauner*

Periodic mesoporous organosilica (PMO) materials feature a unique combination of functional organic units and inorganic cross-linking parts within their periodically structured frameworks. Li et al. succeeded in the incorporation of large, strongly light absorbing porphyrin units into the walls of a newly designed PMO. Porphyrins are widely used in organic optoelectronics and photovoltaics and are therefore interesting building blocks for the creation of electroactive PMO materials. Thin films of the novel PMO feature accessible interconnected pores, which are large enough to accomodate extended guest molecules, such as soluble fullerene derivatives. Upon incorporation of [6,6]-phenyl C61 butyric acid methyl ester (PCBM) an ordered three-dimensional heterojunction was formed. The authors found that upon illumination this material was capable of transferring electrons to the pore-located acceptor molecules, which resulted in the first demonstration of a PMO-based photovoltaic device.



Grazing-incidence small-angle X-ray scattering pattern illustrating the high degree of order in the vertically oriented mesoporous organosilica film.

Y. Li, F. Auras, F. Loebermann, M. Doeblinger, J. Schuster, L. Peter, D. Trauner, and T. Bein: *A Photoactive Porphyrin-Based Periodic Mesoporous Organosilica Thin Film;* Journal of the American Chemical Society 135 (49), 18513-18519 (2013).

EVIDENCE FOR DIRAC FERMIONS AND MOTT INSULATING STATES IN (111) ORIENTED $(LaAlO_3)_M/(SrTiO_3)_N$ SUPERLATTICES FROM CORRELATED BAND THEORY

PD Dr. Rossitza Pentcheva (LMU Munich, Faculty of Geosciences)
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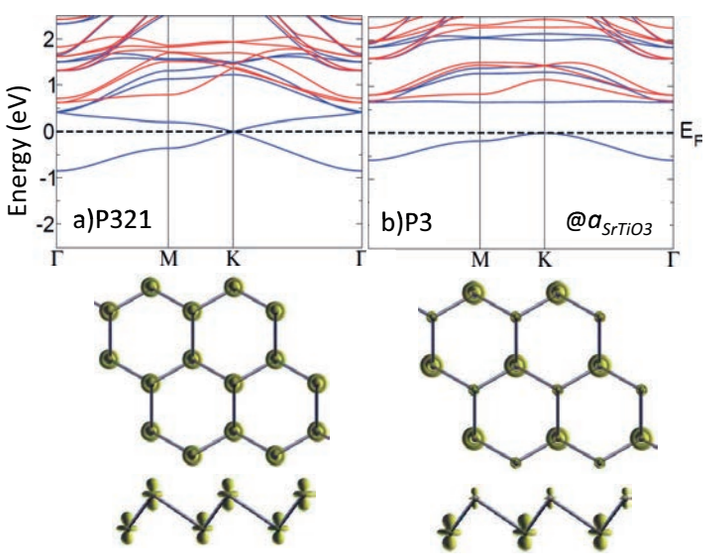
In recent years, topological insulators (TI) with their protected edge states, and atomic layer-by-layer design of oxide interfaces with unexpected and exotic electronic phases, have been two areas of great excitement and intense research. So far, most of the research on TIs concentrates on binary semiconductor phases with strong spin-orbit coupling. In the field of oxide interfaces recent interest was directed at (001) perovskite interfaces as the ones between the band insulators $LaAlO_3$ and $SrTiO_3$, showing unexpected functionalities like two-dimensional conductivity, superconductivity and magnetism. Here we focus on $LaAlO_3/SrTiO_3$ superlattices with (111) crystallographic orientation and explore the possibility to achieve topological behavior, based on material-specific density functional theory calculations, including an on-site Coulomb repulsion parameter. A set of unusual electronic phases emerges as a result of the interplay of confinement, electronic interactions, symmetry breaking, polarity mismatch and strain. The results show that a selective orbital reconstruction of the t_{2g} manifold (e_g', a_{1g} , or d_{xy}) can be engineered by strain. The bilayer $SrTiO_3$(111) quantum well under tensile strain represents an interesting case, as the Ti ions build a buckled honeycomb lattice. Here a Dirac-point Fermi surface is stabilized with two linearly crossings bands at K, similar to graphene. Symmetry breaking leads to two inequivalent interfaces resulting in a charge ordered (Ti^{3+} and Ti^{4+}) multiferroic (ferromagnetic and ferroelectric) flat band insulator. Increasing the thickness of the quantum well leads to a dimensional crossover from an insulator to a metal.

Funding by the DFG (SFB/TR80) is acknowledged.



Band structure and electron density distribution (top and side view), integrated over occupied Ti 3d bands, for a $(LaAlO_3)_4/(SrTiO_3)_2$(111) superlattice under tensile strain. a) Within P321 symmetry the system is a Weyl semimetal with Dirac points (DP) at K, K' as in graphene and an a_{1g} orbital occupation. (b) Allowing breaking of inversion symmetry results in inequivalent interfaces and a flat band insulating state.

D. Doennig, W.E. Pickett and R. Pentcheva: *Massive symmetry breaking in $LaAlO_3/SrTiO_3$(111) quantum wells: a three-orbital, strongly correlated generalization of graphene;* Phys. Rev. Lett. 111,126804 (2013).

ARTIFICIAL SOLIDS BY DESIGN: ASSEMBLY AND ELECTRON MICROSCOPY STUDY OF NANOSHEET-DERIVED HETEROSTRUCTURES

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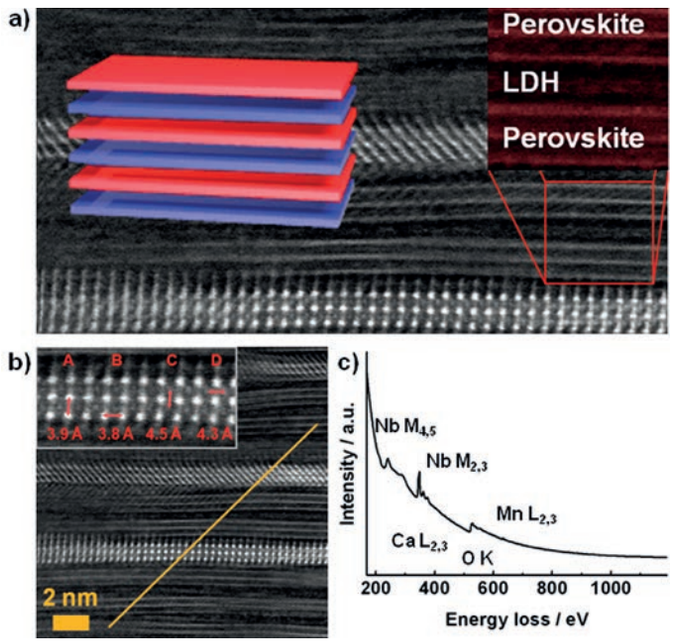
Prof. Christina Scheu (LMU Munich, Department of Chemistry) *www.cup.uni-muenchen.de/pc/scheu*

The rational design of solids with tailor-made properties has been a hallmark of soft chemistry and a major driving force of modern materials science. Stimulated by the rise of nanochemistry and the ability to isolate and manipulate well-defined nanoscale building blocks such as two-dimensional (2D) nanosheets, this project aims for the modular assembly of preformed nano-objects into hierarchical superlattices with engineered properties. To achieve maximum control over the layer sequence, we use an electrostatic layer-by-layer (LBL) procedure to design artificial solids which are otherwise inaccessible due to thermodynamic constraints under high temperature conditions. Here, the bottom-up fabrication of a heterostructure based on positively charged layered double hydroxide (LDH) and negatively charged perovskite layers is presented. A combination of HRTEM, STEM and EEL spectroscopy was used to elucidate the structure and composition of the multilayer stack with a high spatial resolution on the subnanometer scale. Atomic column resolved STEM coupled with EELS line-scans confirmed the periodic arrangement of individual nanosheets by evaluation of the Ca-L2,3 and Mn-$L_{2,3}$ edges. Furthermore, HR-TEM revealed the formation of up to 200 layer thick films, thus demonstrating the transition from ultrathin nanosheet assemblies to artificial bulk solids. The formation of densely packed stacks with a well-ordered layered morphology was ascertained, while non-idealities such as lack of in-plane layer registry, layer terminations, sheet bending and contamination by residual ligands are side effects of the solution-based deposition process. In addition, it was demonstrated that the packing density of the multilayer system can be tuned by changing the LDH dispersing agent from formamide to water, resulting in a dramatic decrease of LDH content and significantly increased interlayer distances and porosity.



(a) STEM image and scheme of a LDH/perovskite multilayer, (b) STEM cross-section image of a $(LDH_{fa}/per)_{100}$ film. The inset shows the vertical (vert) and horizontal (horiz) distances between (A) $Nb–Nb_{horiz}$, (B) $Nb–Nb_{vert}$, (C) $Ca–Ca_{vert}$, and (D) $Ca–Ca_{horiz}$. The orange line corresponds to an EELS line-scan, where (c) shows the sum of the corresponding EEL spectra.

C. Ziegler, S. Werner, M. Bugnet, K. Virdi, M. Wörsching, V. Duppel, G. A. Botton, C. Scheu, B. V. Lotsch: *Artificial solids by Design: Assembly and Electron Microscopy Study of Nanosheet Derived Heterostructures;* Chem. Mater. 25, 4892–4900 (2013).

TOXICITY OF NANOPARTICLES AND HUMAN HEALTH

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In this study it is shown that the cytotoxic response of cells as well as the uptake kinetics of nanoparticles is cell type dependent. Silica nanoparticles with a diameter of 310 nm were used to evaluate cell type dependent uptake and cytotoxicity on human vascular endothelial cells (HUVEC) and cancer cells of the HeLa type.

J. Blechinger, A.T. Bauer, A.A. Torrano, C. Gorzelanny, C. Bräuchle, S.W. Schneider: *Uptake Kinetics and Nanotoxicity of Silica Nanoparticles are Cell Type Dependent;* Small 9(23), 3970 (2013).

Three-dimensional atomic force microscopy is combined with fluorescence microscopy to investigate the cellular uptake of silica nanoparticles into human cells. Nanoparticles (red dots in the image) are visible on the plasma membrane outside of the cells. Interestingly, after longer exposure times, the surface of the cells may also be characterized by homogeneous distribution of small humps, indicating intracellular localization of nanoparticles. Results obtained using this technique confirm that the cellular response to silica nanoparticles is cell type dependent.

Inside cover picture for Small December 2013, 9(23).

TRUE COLOR CONTRAST IN ULTRAMICROSCOPY FOR CHEMICAL IDENTIFICATION ON A 20 NM SCALE

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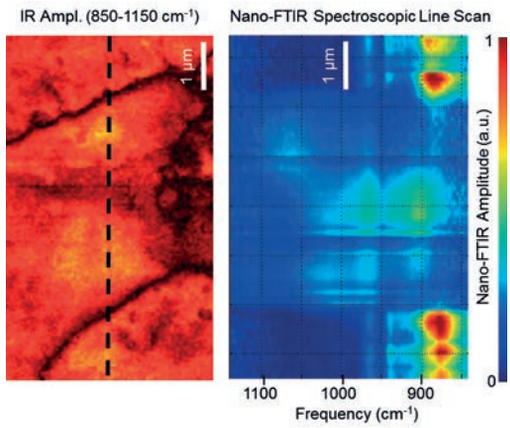
Prof. Rainer Hillenbrand (CIC nanoGUNE San Sebastian, Spain) *www.nanogune.eu/en/research/nanooptics/people/rainer*

Near-field techniques allow to overcome the century-old diffraction limit of the classical optical microscope. A new approach has now empowered the near-field optical microscope (s-SNOM) to perform at all mid-infrared colors simultaneously. By this technique the "fingerprint" spectrum of infrared resonances is assessed at pixel sizes as small as 20 nm, and thus serves to identify the nanoscale chemical composition of virtually any material. A collaborative effort within CeNS including spin-off Neaspec GmbH has proved that the observed resonance shapes are identical to those of classical absorption that are ubiquituously used in automatic chemical recognition routines of modern infrared spectrometers (FTIR). The key technical advances were (i) a coherent mid-infrared continuum source and (ii) an interferometric detection system that determines absorption as the product of the detected scattering-amplitude and the sinus of scattering-phase signals. The novel method termed "nano-FTIR" has been tested with well-defined polymer nanostructures, and applied to naturally occurring nanostructures in shells, human bone, and furthermore, in a single dust grain of extraterrestric origin, recovered 2004 from a comet tail ("star dust" mission by NASA). Among several other observations, the evidence presented for amorphous and crystalline materials coexisting at the micron-scale within a cometary dust grain adds to the mounting evidence for a common history of formation shared by comets and asteroids within the presolar nebula.

Nano-FTIR promises no less than a continuation of the success story of FTIR-based chemical analysis into resolutions hundreds, if not thousands of times better than previously attainable. This poses a highly welcome solution to the nanoanalysis requirements of all nanotechnologies and nanosciences.



Chemical image of a cometary dust grain. Infrared nanoimage (spectrally unresolved, left), and spectral variation along dashed line assessed by nano-FTIR (right), of a polished dust grain collected by NASA from the tail of comet 81P/Wild 2. The upper and lower areas show spectra as known of Forsterite crystals, while the material in between is a sequence of three distinguishable plagioclase and mesostasis glass phases. The abrupt change of spectra on a <100 nm scale is indicative of rapid cooling from a >1000 K temperature. Detailed analysis reveals subtle resonance shifts indicating silicate cation concentration changes at the sub-micron scale.

F. Keilmann, R. Hillenbrand and A.S. McLeod: *Nano-FTIR – the Chemical Nanoscope;* Imaging & Microscopy 1, 26 (2013).

I. Amenabar, S. Poly, W. Nuansing, E. H. Hubrich, A. A. Govyadinov, F. Huth, R. Krutokhvostov, L. Zhang, M. Knez, J .Heberle, A. M. Bittner, and R. Hillenbrand: *Structural analysis and mapping of individual protein complexes by infrared nanospectroscopy;* Nature Comm. 4, 2890 (2013).

ELECTROACTIVE COVALENT ORGANIC FRAMEWORKS

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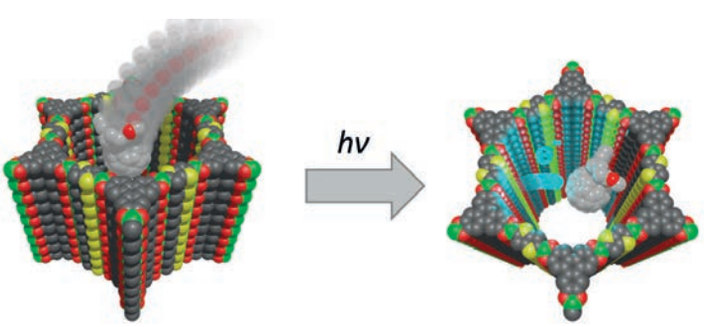
Prof. Achim Hartschuh (LMU Munich, Chemistry Department) *www.cup.uni-muenchen.de/pc/hartschuh*

Covalent Organic Frameworks (COFs) are a class of organic crystalline frameworks linked by covalent bonds. Physical, chemical and optical properties, such as thermal stability, light absorbance and conductivity can be tailored by the choice of the appropriate building blocks. Due to the high internal surface area combined with the well-defined crystalline structure, these materials can be used as model systems to investigate ordered electron donor-acceptor interpenetrated systems. Dogru et al. introduced a novel photoconductive thienothiophene-based covalent organic framework, TT-COF. TT-COF served as a host for electron acceptor molecules, [60]PCBM. Upon illumination charge transfer from the TT-COF to the [60]PCBM was recorded by efficient photoluminescence (PL) quenching. Furthermore, an elaborate PL life-time decay study of the interpenetrated system showed that the PL life time of the [60]PCBM is considerably shorter when incorporated with TT-COF, therefore further indicating a charge transfer. TT-COF was incorporated into a photovoltaic device having an ITO/TT-COF:PCBM/Al architecture, and it is the first demonstration of charge separation and collection in COF-based solar device.



A photoconductive TT-COF hosting a [60] PCBM molecule (left). Upon illumination, charge transfer from TT-COF to the [60] PCBM derivative takes place.

M. Dogru, M. Handloser, F. Auras, T. Kunz, D. Medina, A. Hartschuh, P. Knochel, T. Bein: *A Photoconductive Thienothiophene-Based Covalent Organic Framework Showing Charge Transfer Towards Included Fullerene;* Angew. Chem.Int. Ed. 52(10), 2920-24 (2013).

HIERARCHICAL ASSEMBLY OF METAL NANOPARTICLES, QUANTUM DOTS AND ORGANIC DYES USING DNA ORIGAMI SCAFFOLDS

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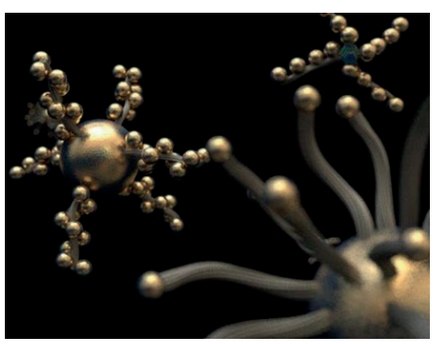
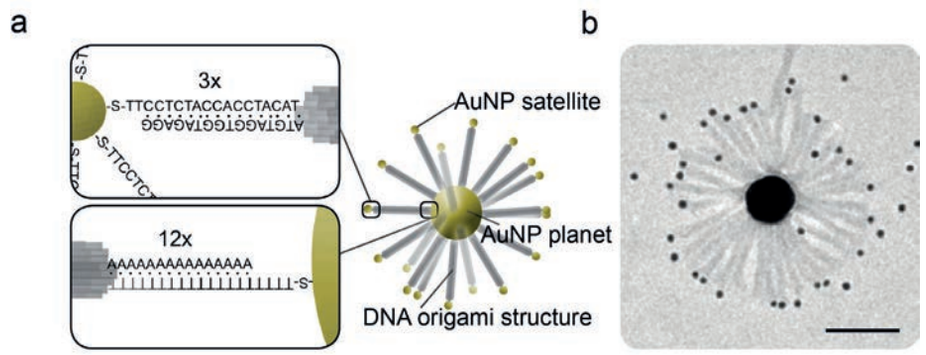
Prof. Tim Liedl (LMU Munich, Faculty of Physics) *www.softmatter.physik.uni-muenchen.de/liedl_group*

DNA-based self-assembly offers the advantage that many identical objects can be fabricated at once while achieving nanometer-precise positioning of objects in all three dimensions. In the past years, many sophisticated assemblies of metal nanoparticles that are based on DNA scaffolding have been realized. These studies used the metal particles mainly as objects to visualize the assembly power of DNA and only very recently function was added by the design of optically active materials. The groups of Tim Liedl and Jochen Feldmann were now able to build a new class of hierarchical assemblies of controllable sizes using colloidal gold, silver and fluorescent nanoparticles and DNA origami structures as robust scaffolding elements. These super-assemblies have a planet-satellite-like appearance, they



Artistic drawing of planet-satellite nanoclusters in solution (Christoph Hohmann/NIM).



Planet-satellite nanoclusters. To create planet-satellite nanostructures a central gold nanoparticle was used as a scaffold to arrange AuNP-functionalized DNA origami structures in space. a, Schematic drawing of a planet-satellite cluster that collapsed onto a surface. Upper zoom-in: 10 nm AuNP satellites functionalized with multiple thiolated DNA strands were hybridized to DNA origami structures (here a 100 nm long 24 helix-bundle). Bottom zoom-in: The 24 helix-bundles were hybridized via DNA strands to the thiol-DNA functionalized AuNP planet. b, TEM image of a planet-satellite nanostructure (planet: 60 nm AuNP, DNA origami structure: 24 helix-bundle, satellites: 10 nm AuNPs). The TEM image shows a collapsed, two-dimensional version of the nanoclusters. Scale bar 100 nm.

are monodisperse in size and their structural integrity is provided by the rigidity of DNA origami constructs and the stability of DNA-origami-enabled connection schemes. The planet-satellite structures formed closely-packed lattices when deposited on surfaces and we were able to measure energy transfer from organic dyes to planet particles. Such hierarchical nanoclusters could find applications as framework for Raman spectroscopy, Fano resonances, light funnelling, catalysis or as plasmonic nanolenses that are based on local field enhancement.

Supported by a CeNS Travel Award: the results of this project were presented on the "Programmable Self-Assembly of Matter" conference in New York City in June 2013 and received a Nature Materials Poster Award. The project was published in the January edition of Nature Nanotechnology as the cover article.

R. Schreiber, J. Do, E. Roller, T. Zhang, V. J. Schüller, P.C. Nickels, J. Feldmann, T. Liedl: *Hierarchical Assembly of Metal Nanoparticles, Quantum Dots and Organic Dyes Using DNA Origami Scaffolds;* Nature Nanotechnology 9, 74-78 (2014) (online publication date: 1st of December 2013).

INVERTED CONICAL GaAS NANOWIRE RESONATORS

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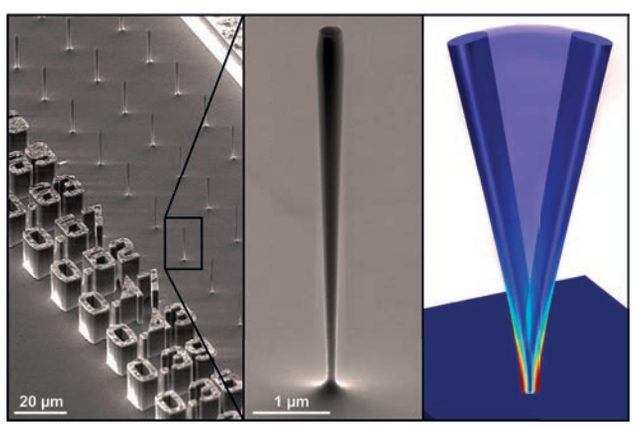
Dr. Philipp Paulitschke & Dr. Heribert Lorenz (LMU Munich, Faculty of Physics) *www.nanophysik.uni-muenchen.de*

Nanomechanical resonators are excellent candidates for sensing devices. One example are top down fabricated, singly clamped inverted conical GaAs nanowires, as their narrow feet enable high force sensitivities while the relatively large nanowire heads allow for standard detection in an optical microscope. As a consequence, inverted conical nanowire arrays are highly promising devices capable of probing minute forces to study, e.g., cellular force exertion even in a liquid environment. In addition, the comparatively large heads allow for precise and reproducible nanowire definition using elec-



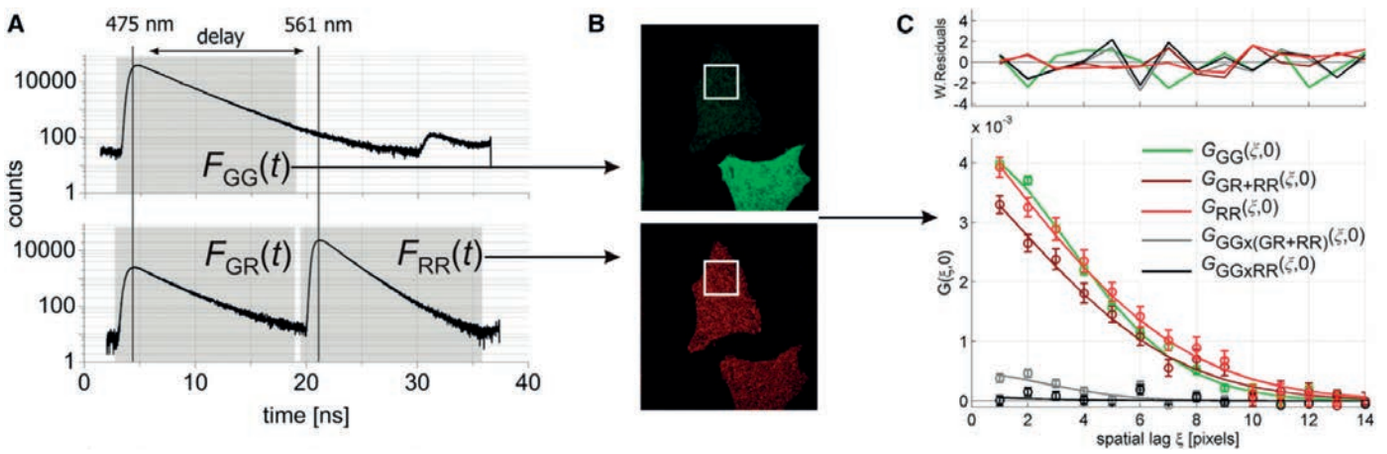
Left: Scanning electron micrograph showing a tilted view of a sample hosting rows of flexible nanowires of 6 µm length with varying diameter. Lithographed numbers refer to head diameter of the respective row of three identical nanowires in micrometers. Middle: Enlarged view of a single nanowire illustrating its inverted conical shape. Right: Illustration of nanowire vibration based on a COMSOL finite element simulation.

tron-beam lithography. Figure 1 shows nanowires etched into a (100)-oriented GaAs substrate, combining the benefits of top down fabrication with an ultrasoft mechanical response, enabling an immediate integration into a sensing array. Notably, the nanowires are not cylindrical, but of inverted conical shape. Combining nanowire lengths of 2–9 µm with foot diameters of 36–935 nm yields nanowires with fundamental flexural eigenmodes spanning two orders of magnitude from 200 kHz to 42 MHz. This comprehensive dataset is compared with an analytic eigenfrequency solution derived from the Euler-Bernoulli boundary value problem for the inverted conical nanowire. This allows to extract a size-independent value of Young's modulus of (45±3) GPa, which forms the basis for the precise calibration of future sensor applications.

P. Paulitschke, N. Seltner, A. Lebedev, H. Lorenz, and E.M. Weig: *Size-independent Young's modulus of inverted conical GaAs nanowire resonators;* Appl. Phys. Lett. 103, 261901 (2013).

PULSED INTERLEAVED EXCITATION FLUCTUATION IMAGING

Prof. Don C. Lamb (LMU Munich, Faculty of Chemistry) *www.cup.uni-muenchen.de/pc/lamb*



Dual-color PIE-RICS experiment in the cytosol of HeLa cells expressing eGFP and mCherry. (A) Logarithmic microtime histograms of the TCSPC data with the different PIE channels (gray). (B) Confocal macrotime images with photons from the eGFP and mCherry PIE channels. (C) Spatial auto- and cross-correlations of eGFP and mCherry PIE channels showing the removal of spectral cross-talk in the cross-correlation RICS analysis.

In PIE, subnanosecond pulsed lasers are used and different colors are alternated on the nanosecond time scale. Recently, fluctuation imaging methods have been developed, that use the information available in images to determine parameters such as concentration, diffusion coefficient, and interactions. By combining the methods, the advantages of both techniques are exploited. The article begins with a proof-of-principle experiment showing that the molecular brightness and diffusion coefficient of Venus fluorescent protein could be determined more robustly by PIE-RICS than in point PIE-FCS measurements. The main advantage of PIE-RICS lies in its application to multicolor experiments eg. for protein-protein interactions in living cells, since PIE provides a crosstalk free cross-correlation analysis and can therefore even be applied for fluorescent proteins with large spectral overlap. In addition, any effects of FRET can be removed from the experimental data. Furthermore, the additional information on fluorescence lifetime available by the use of PIE can be used to quantify FRET in PIE-FI experiments or to separate different species based on their fluorescence lifetime (RLICS). Another fluctuation imaging technique is number and brightness analysis, which allows one to quantify the absolute brightness and concentration of fluctuating molecules. As the method is based on a detailed analysis of the photon counting statistics, for these experiments, care has to be taken and measures need to be applied to correct for the dead time of the detectors and detection electronics. The formalism of the correction is presented and experimentally verified in this publication. Overall, PIE-FI can easily be incorporated into any raster-scanning microscope, enhances the existing fluctuation imaging techniques and shows advantages in the quantitative determination of several parameters, especially for the use of multicolor live-cell experiments.

J. Hendrix, W. Schrimpf, M. Höller, and D.C. Lamb: *Pulsed Interleaved Exciation Fluctuation Imaging;* Biophysical Journal 105, 848 (2013).

GUEST MOLECULES IN STRUCTURED MESOPOROUS MATERIALS

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Prof. Christoph Bräuchle (LMU Munich, Chemistry Department) *www.cup.uni-muenchen.de/pc/braeuchle*
Prof. Jens Michaelis (Universität Ulm, Physics Department) *www.uni-ulm.de/nawi/nawi-biophys.html*
Prof. Joachim Rädler (LMU Munich, Faculty of Physics) *www.softmatter.physik.uni-muenchen.de/*

Controlled endosomal escape has been identified as one of the main bottlenecks in gene and drug delivery. To date, however, there are few papers that report on the real-time monitoring of single endosome lysis due to the low signal-to-noise ratios. Dobay et al. investigated uptake and individual endosome lysis events in fibroblast, normal and carcinoma cell lines using a colloidal mesoporous silica nanoparticle (MSN) based reporter system. Therefore, a mesoporous core-shell system equipped with covalently surface-linked protoporphyrin IX (PpIX) as an on-board photosensitizer (PS) loaded with a redox-active dye/quencher system, and sealed with a supported lipid bilayer (SLB) acting as removable encapsulation was designed. Endosomal lysis was induced through the activation of protoporphyrin IX (PpIX). This release-on-demand system resulted in more broadly-distributed lysis times than expected, particularly for Renca, a renal carcinoma cell line. The analysis of the MSN load per endosome, endosome size and uptake characteristics indicate that Renca cells not only take up a lower amount of MSNs in comparison with the fibroblast cells, but also have larger endosomes, and a lower MSN-load per endosome. Dobay et al. extended an existing stochastic pi calculus model of gold nanoparticle intracellular distribution to understand how much factors that cannot be directly measured, such as variations in the PpIX load per NP, affect the distributions. Model results indicate that the lysis time distribution is primarily determined by the minimum net PpIX required to burst an endosome, a factor influenced by the NP load per endosome, as well as the endosome size.

Colloidal mesoporous silica core-shell nanoparticles (MSNs) have attracted great attention in recent years as versatile vehicles for drug delivery. MSNs offer a high pore volume, defined and tunable pore sizes and various functionalization possibilities of the inner and outer surface. Photochemical internalization (PCI) with photosensitizers (PS) allows to overcome endosomal entrapment, a major bottle-neck in drug delivery.

Mackowiak et al. present a multifunctional mesoporous core-shell system with surface-bound PEG and covalently attached red-light sensitive phthalocyanine photosensitizer AlPcS2a, excitable near the therapeutic window. Longer wavelengths provide a better biocompatibility and allow for a deeper penetration into tissues.

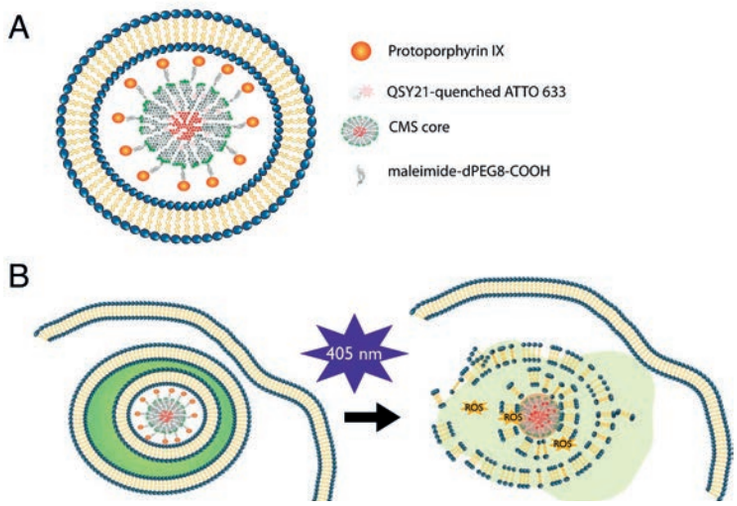

Figure 1. *Mesoporous silica nanoparticle based endosome lysis detector system: The reactive oxygen species (ROS) produced by the on-board photosensitizer (Protoporphyrin IX) oxidize double bonds in the lipid bilayer around the nanoparticles (NPs) in both the SLB surrounding the NPs, as well as of the endosome. Following membrane disruption, the reductive intracellular milieu cleaves the bonds between the quencher and ATTO633, leading to localized fluorescence at the site of lysis.*

The silica nanoparticles are surrounded by a supported DOPC/DOTAP lipid bilayer (SLB) for efficient encapsulation of the guests (calcein and rhodamine derivative). The tight lipid shell is acting as a biocompatible and removable encapsulation for non-membrane permeable cargos and improves the dispersibilty of the MSN particles. Additionally, two different targeting ligands, folic acid (FA) and epidermal growth factor (EGF) were inserted via diffusion into the SLB@MSN. These targeting ligands were chosen because their receptors are commonly overexpressed in a wide range of cancer cells. Cellular uptake of targeted MSNs into KB and HeLa cells were monitored with fluorescence live-cell-imaging. Singlet oxygen is generated by photoactivation and leads to endosomal membrane rupture in cells causing cargo release from the mesopores. The successful intracellular release of the encapsulated guests was monitored by fluorescent microscopy.

Torrano et al. developed a novel method to examine the absolute quantification of particle uptake into single cells from dual-color confocal images in a semiautomatic way. They analyzed stacks of confocal fluorescence images of single cells interacting with nano-sized particles. Hence, mesoporous silica nanoparticles (MSNs) coated with poly (ethylene glycol) (PEG) were fluorescently labeled with cy3 dye molecules. These PEGylated nanoparticles provide high monodispersity and

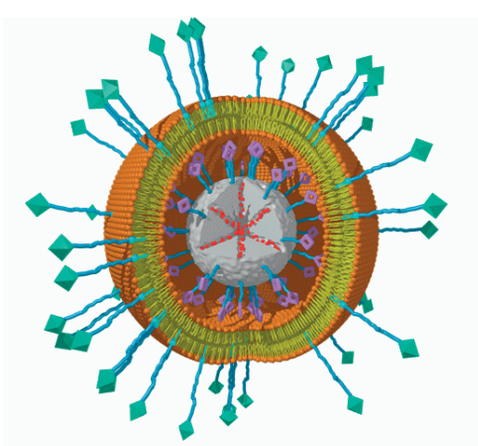

Figure 2. *Schematic design of our multifunctional mesoporous silica based drug delivery vehicle equipped with an on-board red-light sensitive photosensitizer and a highly biocompatible supported lipid bilayer. Different targeting ligands (Folic Acid and EGF) have been attached onto the outer surface of the particle to enable specific cellular uptake into cancer cells.*

improved colloidal stability in aqueous solution offering great potential for efficient and non-agglomerated cellular uptake. During the image analysis routine, single cells were reconstructed in 3D and split into two volumes – intracellular and the membrane region. Next, particles were localized and color-coded accordingly. The mean intensity of single particles, measured in calibration experiments, was used to determine the absolute number of particles. The Particle_in_Cell-3D macro was successfully applied to measure the uptake of 80-nm MSNs into HeLa cells. Furthermore, it was used to quantify the absolute number of 100-nm polystyrene nanoparticles forming agglomerates of up to five particles. These results have been proven by comparison with STED microscopy, a super-resolution technique. Particle_in_Cell-3D overcomes some drawbacks of commonly applied methods such as flow cytometry, electron microscopy and single-cell quenching experiments, offering new possibilities to characterize particle–cell interactions. Potential applications of this method include studies to establish dose-dependent effects for the risk assessment of nanomaterials. In addition, Particle_in_Cell-3D can be used to investigate which factors determine the successful attachment and internalization of nano- and micro-sized particles designed for drug and gene delivery therapies. In summary, Particle_in_Cell-3D is a freely available ImageJ macro and is a fast and accurate method that allows the quantification of particle uptake into cells.

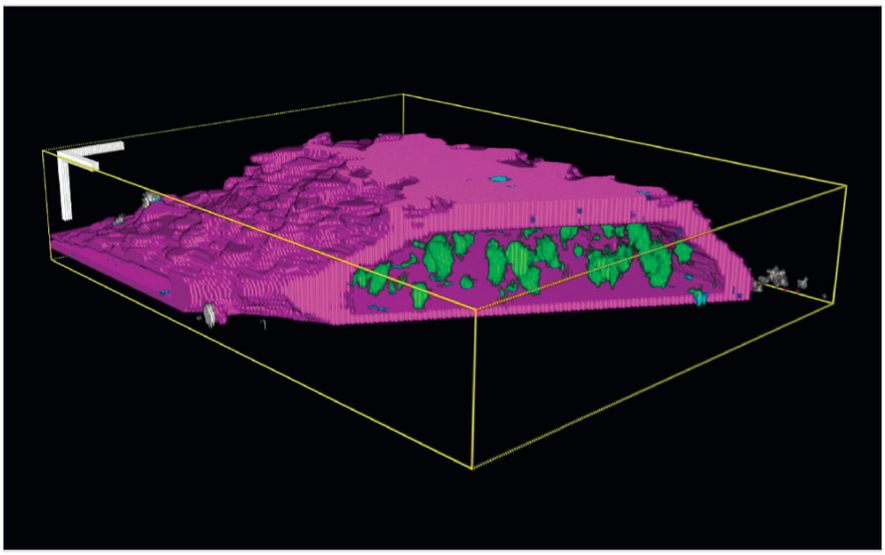

Figure 3. *Transversal cut of a 3D representation of nanoparticle uptake after evaluation with Particle_in_Cell-3D. Cellular boundaries were reconstructed by the membrane region and are shown in magenta. The analyzed nanoparticles are color-coded in green if intracellular and in cyan if membrane associated; nanoparticles lying outside the cell volume are displayed in gray. The projection was created with the ImageJ plugin 3D Viewer. 3D scale bars are 4 µm.*

M.P. Dobay, A. Schmidt, E. Mendoza, T. Bein, J.O. Rädler: *Cell Type Determines the Light-Induced Endosomal Escape Kinetics of Multifunctional Mesoporous Silica Nanoparticles;* Nano Letters 13 (3), 1047-1052 (2013).

S.A. Mackowiak, A. Schmidt, V. Weiss, C. Argyo, C. von Schirnding, T. Bein, and C. Bräuchle: *Targeted Drug Delivery in Cancer Cells with Red-Light Photoactivated Mesoporous Silica Nanoparticles;* Nano Letters 13 (6), 2576-2583 (2013).

B. Rühle, M. Davies, T. Bein, and C. Bräuchle: *Fluorescence Microscopy Studies of Porous Silica Materials;* Zeitschrift Für Naturforschung Section B - a Journal of Chemical Sciences 8 (5-6), 423-444 (2013).

A.A. Torrano, J. Blechinger, C. Osseforth, C. Argyo, A. Reller, T. Bein, J. Michaelis, and C. Bräuchle: *A fast analysis method to quantify nanoparticle uptake on a single cell level;* Nanomedicine (London, England) 8(11), 1815-1828 (2013).

VISUALIZING ENZYMATIC ACTIVITY AT LOWEST CONCENTRATIONS BY SMCP INTO NANO-APERTURES

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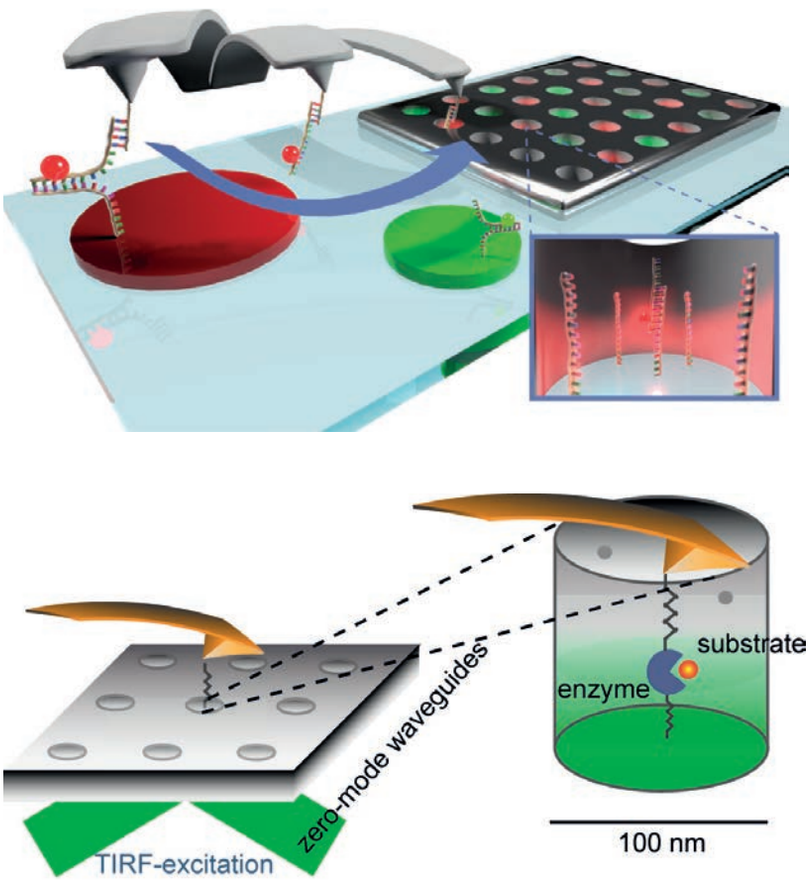
Single-molecule force spectroscopy (SMFS) with the atomic force microscope measures the response of individual biomolecules to force [1], while high resolution fluorescence experiments can be employed to study enzymatic activity on the level of single molecules. Measurement of binding events to single enzymes is often hampered by background fluorescence from the bulk. With the goal of arranging individual enzymes on surfaces and studying their force-activated binding behavior, this project's goal is to use Single-Molecule Cut-and-Paste (SMCP) to individually transfer enzymes of interest to the center of nanoapertures in Zero-Mode Waveguides (ZMW) [2]. Such apertures have a restricted excitation volume and require a special design, which allows the tip of the cantilever to protrude into it. These nanophotonic devices have great potential for single-molecule fluorescence studies when circumventing metallic quenching and steric hindrance by exactly centered immobilization of the molecule of interest. By comparing their fluorescence lifetime and intensity to stochastically immobilized fluorophores, the electrodynamic environment in these nanoapertures was characterized and the nanometer precision of the SMCP method was proven. Now equipped for single enzymatic experiments, the binding of fluorescent adenosine triphosphate (ATP) to the force-activated enzyme titin kinase was assessed. According to the mechanical forces applied through the force sensor to the titin kinase, its enzymatic activity simultaneously was monitored by the fluorescence signal [3].



Single Molecule Cut & Paste (SMCP) arranges bio-molecules (here with red or green fluorophores) into nano-apertures of Zero Mode Wave Guides at nm precision (A).The force sensor modulates a force-activated enzyme while the optical readout reports on enzyme activity (B).

[1] M.A. Jobst, C. Schoeler, K. Malinowska, M. A. Nash: *Investigating Receptor-ligand Systems of the Cellulosome with AFM-based Single-molecule Force Spectroscopy;* JoVE (2013).

[2] Heucke S.F., Baumann F., Acuna G.P., Severin P., Stahl S.W., Strackharn M., Stein I., Altpeter P., Tinnefeld P. and Gaub H.E.: *Placing individual molecules in the center of nanoapertures;* Nano Letters, Articles ASAP (2013).

[3] Heucke S.F., Puchner E.M., Stahl S.W., Holleitner A.W., Gaub H.E. and Tinnefeld P.: *Nanoapertures for AFM-Based Single-Molecule Force Spectroscopy;* Int. J. Nanotechnology 10, No. 5/6/7, 607–619 (2013).

CONFORMATIONAL DYNAMICS OF MITOCHONDRIAL HSP70 BY SPFRET

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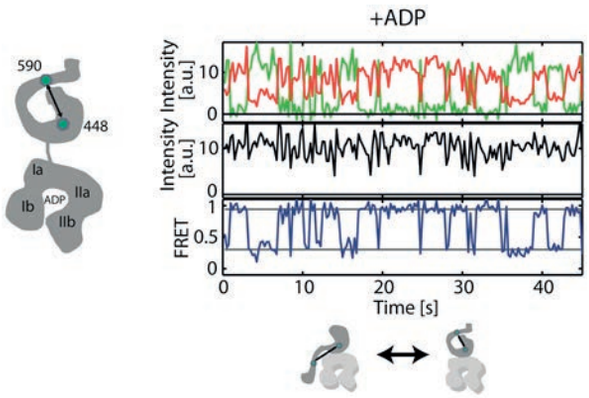
The mitochondrial chaperone Ssc1 is a Hsp70 type of chaperone, which aids many proteins during the maturation process. As other heat shock proteins, it relys on a conformational cycle based on ATP hydrolysis to perform its function. Conformational transitions throughout this cycle were studied using single pair Förster resonance energy transfer on a total internal reflection microscope to observe the dynamics between the functional subunits of the protein. The positions of FRET pairs on the chaperone were chosen to monitor the distance between the nucleotide-binding domain and the substrate-binding domain on one hand and, in the second case, between the α-helical lid and the β-sheet of the substrate-binding domain (see Figure). In the presence of ADP, dynamic motions of the opening of the substrate-binding domain itself and of the interaction between the domains were observed. The different time-scales of these motions, however, led to the conclusion that these conformational transitions are not directly coupled. In the presence of ATP, conformational transitions could only be observed for the interdomain distance, whereas the conformation of the lid was static. The addition of substrate peptide always led to the stabilization of static FRET states. Furthermore, the docking of the domains was dependent on ADP concentration while the undocking was independent of nucleotide concentration, suggesting a nucleotide-free intermediate FRET population. Investigation of these rates in the presence of the nucleotide-exchange factor Mge1 demonstrated, that Mge1 stimulates ATP binding rather than the release of ADP from Ssc1. After characterizing the different conformations of the chaperone, all the steps in the conformational cycle were monitored using spFRET by including all components (Ssc1, substrate peptide, ATP) in 200 nm vesicles. It was observed, that the peptide only bound to the nucleotide-bound state. These results indicate a highly elaborate conformational cycle of the mitochondrial Hsp70 and provide potential evidence for the mechanism of the large variety of functions performed by these chaperones.



Representative time trace of donor and acceptor intensity, total intensity, and FRET efficiency of a spFRET TIRF experiment of the distance within the substrate-binding domain in the presence of ADP. Fluorophores are positioned on Ssc1 at residues C448 and C590. The acceptor-donor labeled chaperones are measured in the presence of 1 mM ADP with 250 ms excitation per frame. The lower panel shows a schematic representation of the transitions in the substrate-binding domain.

M. Sikor, K. Mapa, L. Voith von Voithenberg, D. Mokranjac, and D.C. Lamb: *Real-time observation of the conformational dynamics of mitochondrial Hsp70 by spFRET;* EMBO J 32(11), 1639 (2013).

SIZE DISTRIBUTION ANALYSIS OF VON WILLEBRAND FACTOR

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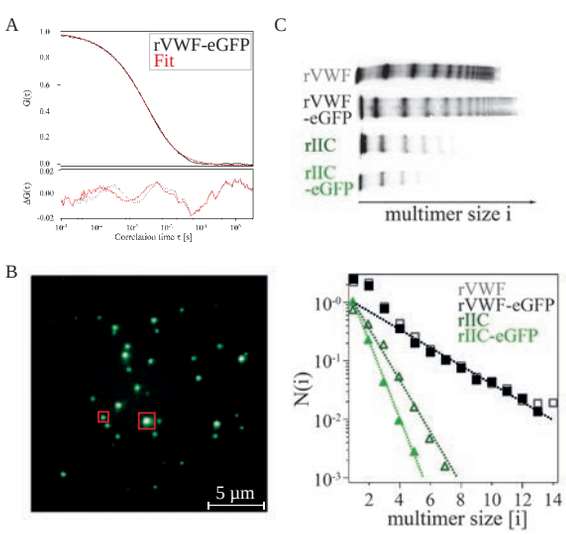
Dr. Martin Benoit (LMU Munich, Faculty of Physics) *www.biophysik.physik.uni-muenchen.de/personen/group_leader/benoit_martin*

The blood protein von Willebrand Factor (VWF) is required for the initiation of coagulation as it promotes platelet adhesion at sites of vascular injury. VWF is a multimeric, multifunctional, mechanosensitive protein and, remarkably, its function in primary hemostasis strictly correlates with its size. From a polymer physics point of view, the size dependent functionality is of eminent interest, because VWF's size distribution significantly triggers the influence of shear flow on its activity. However, there was hitherto no quantitative description on the size distribution. To close this gap, multiple experimental approaches were carried out involving quantitative gel analysis, fluorescence correlation spectroscopy (FCS) and single-molecule photo bleaching using total internal reflection fluorescence microscopy (TIRFM). The combination of these techniques provided evidence for an exponential size distribution, which is in accordance with a step-growth polymerization process during VWF biosynthesis. A single parameter, the degree of polymerization, explicitly describes the size distribution. For a disease-related VWF mutant, the parameter was found to be reduced, which suggests it as diagnostic measure. The quantitative assessment of the VWF size distribution in terms of an exponential might prove to be useful both as biophysical characterization and as a possible disease indicator for clinical applications.



Size distribution analysis of VWF using (A) FCS, (B) TIRFM, and (C) Quantitative Gel Analysis. The experiments showed independent evidence of an exponentially decaying size distribution for recombinant VWF as well as for VWF derived from blood samples in accordance with the notion of a step-growth polymerization process during VWF biosynthesis.

S. Lippok, T. Obser, J.P. Müller, V.K. Stierle, M. Benoit, U. Budde, R. Schneppenheim, and J.O. Rädler: *Exponential Size Distribution of von Willebrand Factor;* Biophysical Journal 105, 1208-1216 (2013).

SELECTED PUBLICATIONS

SELECTED PUBLICATIONS

A.K. Austen , C. Kluger, A. Freikamp , A. Chrostek-Grashoff and C. Grashoff: *Generation and analysis of biosensors to measure mechanical forces within cells;* Methods Mol Biol 1066, 169-184 (2013).

B.N. Balzer, M. Gallei, M. Hauf, M. Stallhofer, L. Wiegleb, A. Holleitner, M. Rehahn and T. Hugel: *Nanoscale Friction Mechanisms at Solid–Liquid Interfaces;* Angew. Chem. Int. Ed. 52, 25, 6541 (2013).

B.N. Balzer, M. Gallei, K. Sondergeld, M. Schindler, P. Müller-Buschbaum, M. Rehahn and T. Hugel: *Cohesion Mechanisms of Polystyrene-Based Thin Polymer Films;* Macromolecules 46 (18), 7406 (2013).

F. Bauer, J. Heyder, E. Schubert, D. Borowsky, D. Taubert, B. Bruognolo, D. Schuh, W. Wegscheider, J. von Delft and S. Ludwig: *The Microscopic Origin of the 0.7-Anomaly in Quantum Point Contacts;* Nature 501, 73 (2013).

J. Blechinger, A.T. Bauer, A.A. Torrano, C. Gorzelanny, C. Bräuchle and S.W. Schneider: *Uptake Kinetics and Nanotoxicity of Silica Nanoparticles are Cell Type Dependent;* Small 9 (23), 3970 (2013).

S. Böcklein, S. Günther, R. Reichelt, R. Wyrwich, M. Joas, C. Hettstedt, M. Ehrensperger, J. Sicklinger and J. Wintterlin: *Detection and quantification of steady-state ethylene oxide formation over an Ag(111) single crystal;* J. Catal. 299, 129 (2013).

A. Bora, A. Pathak, K.-C. Liao, M.I. Vexler, A. Kuligk, A. Cattani-Scholz, B. Meinerzhagen, G. Abstreiter, J. Schwartz and M. Tornow: *Organophosphonates as model system for studying electronic transport through monolayers on SiO_2/Si surfaces;* Appl. Phys. Lett. 102, 241602 (2013).

A.S. Critchfield, G. Yao, A. Jaishankar, R.S. Friedlander, O. Lieleg, P.S. Doyle, G. McKinley, M. House and K. Ribbeck: *Cervical Mucus Properties Stratify Risk for Preterm Birth;* PLoS ONE, 8(8) e69528 (2013).

A. Czogalla, E.P. Petrov, D.J. Kauert, V. Uzunova, Y. Zhang, R. Seidel and P. Schwille: *Switchable domain partitioning and diffusion of DNA origami rods on membranes;* Faraday Discuss 161, 31-43 (2013).

M.P. Dobay, A. Schmidt, E. Mendoza, T. Bein and J.O. Raedler: *Cell Type Determines the Light-Induced Endosomal Escape Kinetics of Multifunctional Mesoporous Silica Nanoparticles;* Nano Letters 13 (3), 1047-1052 (2013).

D. Doennig, W. Pickett, and R. Pentcheva: *Massive Symmetry Breaking in $LaAlO_3$/$SrTiO_3$(111) Quantum Wells: A Three-Orbital Strongly Correlated Generalization of Graphene;* Phys. Rev. Lett. 111, 126804 (2013).

M. Dogru, M. Handloser, F. Auras, T. Kunz, D. Medina, A. Hartschuh, P. Knochel and T. Bein: *A Photoconductive Thienothiophene-Based Covalent Organic Framework Showing Charge Transfer Towards Included Fullerene;* Angewandte Chemie International Edition 52 (10), 2920-2924 (2013).

M. Dogru, A. Sonnauer, S. Zimdars, M. Doeblinger, P. Knochel and T. Bein: *Facile synthesis of a mesoporous benzothiadiazole-COF based on a transesterification process;* CrystEngComm 15 (8), 1500-1502 (2013).

G. Eder, E.F. Smith, I. Cebula, W.M. Heckl, P.H. Beton and M. Lackinger: *Solution Preparation of Two-Dimensional Covalently Linked Networks by Polymerization of 1,3,5-Tri(4-Iodophenyl)Benzene on Au(111);* ACS Nano 7, 3014 (2013).

D. Edinger, R. Kläger, C. Troiber, C. Dohmen and E. Wagner: *Gene Silencing and Antitumoral Effects of Eg5 or Ran siRNA Oligoaminoamide Polyplexes;* DDTR online (2013).

D.J. Egger and F.K. Wilhelm: *Multimode circuit quantum electrodynamics with hybrid metamaterial transmission lines;* Phys. Rev. Lett. 111, 163601 (2013).

N. Erhard, P. Seifert, L. Prechtel, S. Hertenberger, H. Karl, G. Abstreiter, G. Koblmueller and A.W. Holleitner: *Ultrafast photocurrents and THz generation in single InAs nanowires;* Annalen der Physik 1-2, 180-188 (2013).

T. Faust, J. Rieger, M. J. Seitner, J.P. Kotthaus and E.M. Weig: *Coherent control of a classical nanomechanical two-level-system;* Nat. Phys. 9, 485-488 (2013).

Z. Fei, A.S. Rodin, W. Gannett, S. Dai, W. Regan, M. Wagner, M. K. Liu, A.S. McLeod, G. Dominguez, M. Thiemens, Antonio H. Castro Neto, F. Keilmann, A. Zettl, R. Hillenbrand, M.M. Fogler and D.N. Basov: *Electronic and plasmonic phenomena at graphene grain boundaries;* Nature Nanotech. 8, 821 (2013).

T. Freisinger, B. Klünder, J. Johnson, N. Müller, G. Pichler, G. Beck, M. Costanzo, C. Boone, R.A. Cerione, E. Frey and R. Wedlich-Söldner: *Establishment of a robust single axis of cell polarity by coupling of multiple positive feedback loops;* Nature Communications 4,1807 (2013).

T. Fukuhara, A. Kantian, M. Endres, M. Cheneau, P. Schauss, S. Hild, C. Gross, U. Schollwöck, T. Giamarchi, I. Bloch and S. Kuhr: *Quantum dynamics of a mobile single-spin impurity;* Nature Physics 9, 235 (2013).

A. Godec and R. Metzler: *Linear response, fluctuation-dissipation relation, and finite system size effects in superdiffusion;* Phys. Rev. E 88, 012116 (2013).

A.A. Govyadinov, I. Amenabar, F. Huth, P. S. Carney and R. Hillenbrand: *Quantitative Measurement of Local Infrared Absorption and Dielectric Function with Tip-Enhanced Near-Field Microscopy;* J. Phys. Chem. Letters 4, 1526 (2013).

A.X. Gray, J. Minár, L. Plucinski, M. Huijben, A. Bostwick, E. Rotenberg, S.-H. Yang, J. Braun, A. Winkelmann, G. Conti, D. Eiteneer, A. Rattanachata, A.A. Greer, G. Rijnders, D.H.A. Blank, D. Doennig, R. Pentcheva, C.M. Schneider, H. Ebert and C.S. Fadley: *Momentum-Resolved Electronic Structure at a Buried Interface from Soft X-ray Standing-Wave Angle-Resolved Photoemission;* EPL 104, 17004 (2013).

S. Günther, S. Böcklein, J. Wintterlin, M.A. Nino, T.O. Mentes and A. Locatelli: *Locating catalytically active oxygen on Ag(111) - a spectromicroscopy study;* ChemCatChem 5, 3342 (2013).

E. Hebisch, J. Knebel, J. Landsberg, E. Frey and M. Leisner: *High variation of fluorescence protein maturation times in closely related Escherichia coli strains;* PLOS ONE 8(10), e75991 (2013).

** CeNS Publication Award*

J. Hendrix, W. Schrimpf, M. Höller, D.C. Lamb: *Pulsed Interleaved Exciation Fluctuation Imaging;* Biophysical Journal 105, 848 (2013).

S. Heucke, F. Baumann, G. Acuna, P. Severin, S. Stahl, M. Strackharn, I. Stein, P. Altpeter, P. Tinnefeld and H.E. Gaub: *Placing Individual Molecules in the Center of Nanoapertures;* Nano Lett. (2013) [Epub ahead of print].

S.F. Heucke, E.M. Puchner, S.W. Stahl, A.W. Holleitner, H.E. Gaub and P. Tinnefeld: *Nanoapertures for AFM-based single-molecule force spectroscopy;* International Journal of Nanotechnology 10, 5-7 (2013).

L.C. Hinkofer, S.A.I. Seidel, B. Korkmaz, F. Silva, A.M. Hummel, D. Braun, D.E. Jenne and U. Specks: *A monoclonal antibody (MCPR3-7) interfering with the activity of proteinase 3 by an allosteric mechanism;* Journal of Biological Chemistry 288, 26635-26647 (2013).

F. M. Hinterholzinger, B. Rühle, S. Wuttke, K. Karaghiosoff and T. Bein: *Highly sensitive and selective fluoride detection in water through fluorophore release from a metal-organic framework;* Sci Rep 3, 2562 (2013).

M.S. Hofmann, J.T. Glückert, J. Noé, C. Bourjau, R. Dehmel and A. Högele: *Bright, long-lived and coherent excitons in carbon nanotube quantum dots;* Nature Nanotechnology 8, 502-505 (2013).

M. Javanainen, H. Hammaren, L. Monticelli, J.-H. Jeon, R. Metzler and I. Vattulainen: *Anomalous and normal diffusion of proteins and lipids in crowded lipid membranes;* Faraday Discussions 161, 397 (2013).

J-.H. Jeon, N. Leijnse, L. Oddershede and R. Metzler: *Anomalous diffusion and power-law relaxation in wormlike micellar solution;* New J. Phys. 15, 045011 (2013).

S. C. Junggeburth, L. Diehl, S. Werner, V. Duppel, W. Sigle and B. V. Lotsch: *Ultrathin 2D coordination polymer nanosheets by surfactant-mediated synthesis;* J. Am. Chem. Soc. 135, 6157–6164 (2013).

E.M. Kendirlik, S. Sirt, S.B. Kalkan, W. Dietsche, W. Wegscheider, S. Ludwig and A. Siddiki: *Anomalous resistance overshoot in the integer quantum Hall effect;* Nature Sci. Rep. 3, 3133 (2013).

S. Kesel, A. Mader, C. Höfler, T. Mascher and M. Leisner: *Immediate and heterogeneous response of the LiaFSR two-component system of Bacillus subtilis to the peptide antibiotic bacitracin;* PLOS ONE 8(1), e53457 (2013).

S. Kienle, T. Pirzer, S. Krysiak, M. Geisler and T. Hugel: *Measuring the interaction between ions, biopolymers and interfaces – one polymer at a time;* Faraday Disc 160, 329 (2013).

J. Knebel, T. Krüger, M.F. Weber and E. Frey: *Coexistence and survival in conservative Lotka-Volterra networks;* Phys. Rev. Lett. 110, 168106 (2013).

P. Kos, C. Scholz, E.E. Salcher, A. Herrmann and E. Wagner: *Gene transfer with sequence-defined oligo(ethanamino)amides bioreducibly attached to a polypropylenimine dendrimer core;* Pharm Nanotechnology 1, 269-281 (2013).

A. Kuhn, V. Duppel and B.V. Lotsch: *Tetragonal $Li_{10}GeP_2S_{12}$ and Li_7GePS_8 – exploring the Li ion dynamics in LGPS Li electrolytes;* Energy Environ. Sci. 6, 3548–3552 (2013).

U. Lächelt, P. Kos, F.M. Mickler, A. Herrmann, E.E. Salcher, W. Rödl, N. Badgujar, C. Bräuchle and E. Wagner: *Fine-tuning of proton sponges by precise diaminoethanes and histidines in pDNA polyplexes;* Nanomedicine NBM 10, 35–44 (2014).

B. Lake, D.A. Tennant, J.-S. Caux, T. Barthel, U. Schollwöck, S.E. Nagler and C.D. Frost: *Multispinon continua at zero and finite temperature in a near-ideal Heisenberg chain;* Phys. Rev. Lett. 111, 137205 (2013).

N. Lämmerhardt, S. Merzsch, J. Ledig, A. Bora, A. Waag, M. Tornow and P. Mischnick: *Toward Three-Dimensional Microelectronic Systems: Directed Self-Assembly of Silicon Microcubes via DNA Surface Functionalization;* Langmuir 29, 8410–8416 (2013).

Y. Li, F. Auras, F. Loebermann, M. Doeblinger, J. Schuster, L. Peter, D. Trauner and T. Bein: *A Photoactive Porphyrin-Based Periodic Mesoporous Organosilica Thin Film;* Journal of the American Chemical Society 135 (49), 18513-18519 (2013).

K. Limmer, D. Aschenbrenner and H.E. Gaub: *Sequence-specific inhibition of Dicer measured with a force-based microarray for RNA ligands;* Nucleic Acids Research 41(6) e69 (2013).

S.A. Mackowiak, A. Schmidt, V. Weiss, C. Argyo, C. von Schirnding, T. Bein and C. Bräuchle: *Targeted Drug Delivery in Cancer Cells with Red Light Photoactivated Mesoporous Silica Nanoparticles;* Nano Letters 13(6, 2576 (2013).

S. Mackowiak and C. Bräuchle: *Study of Single Molecule Dynamics in Mesoporous Systems, Glasses and Living Cells;* in "Nonequilibrium Statistical Physics of Small Systems: Fluctuation relations and beyond", Eds.: R. Klages, W. Just, C. Jarzynski, Wiley-VCH Weinheim, 393 (2013).

C.B. Mast, S. Schink, U. Gerland and D. Braun: *Escalation of Polymerization in a Thermal Gradient;* PNAS 110, 8030-8035 (2013).

S.A. Maurer, M. Beer, D.S. Lambrecht and C. Ochsenfeld: *Linear-Scaling Symmetry-Adapted Perturbation Theory with Scaled Dispersion;* J. Chem. Phys. 139, 184104 (2013).

M. Maurer and C. Ochsenfeld: *A linear- and sublinear-scaling method for calculating NMR-shieldings in atomic orbital-based second-order Møller-Plesset perturbation theory;* J. Chem. Phys. 138, 174104 (2013).

K. Moeller and T. Bein: *Mesoporosity - a new dimension for zeolites;* Chemical Society Reviews 42 (9), 3689-3707 (2013).

F. Motzoi and F.K. Wilhelm: *Improving frequency selection of driven pulses using derivative-based transition suppression;* Phys. Rev. A 88, 062318 (2013).

P. Nalbach, J. Knorzer and S. Ludwig: *Nonequilibrium Landau-Zener-Stuckelberg spectroscopy in a double quantum dot;* Phys. Rev. B 87, 165425 (2013).

Z. Novotny, N. Mulakaluri, M. Schmid, R. Pentcheva, U. Diebold and G.S. Parkinson: *Probing the surface phase diagram of $Fe_3O_4(001)$ towards the Fe rich limit: Evidence for progressive reduction of the surface;* Phys. Rev. B 87, 195410 (2013).

L. Osinkina, S. Carretero-Palacios, J. Stehr, A.A. Lutich, F. Jäckel, and J. Feldmann: *Tuning DNA Binding Kinetics in an Optical Trap by Plasmonic Nanoparticle Heating;* Nano Letters 13(7), 3140–3144 (2013).

K. Otte, W.W. Schmahl and R. Pentcheva: *DFT+U Study of Arsenate Adsorption on FeOOH Surfaces: Evidence for Competing Binding Mechanism;* J. Phys. Chem. C 117, 15571 (2013).

M. Otten, P. Wolf and H.E. Gaub: *Protein-DNA force assay in a microfluidic format;* Lab Chip 13(21), 4198-204 (2013).

S. Parui, P.S. Klandermans, S. Venkatesan, C. Scheu and T. Banerjee: *Hot electron attenuation of direct and scattered carriers across an epitaxial Schottky interface;* J Phys Condens Matter 25(44), 445005 (2013).

P. Paulitschke, N. Seltner, A. Lebedev, H. Lorenz and E.M. Weig: *Size independent Young's modulus of inverted conical GaAs nanowire resonators;* Appl. Phys. Lett. 103, 261901 (2013).

G. Petersen, E.A. Hoffmann, D. Schuh, W. Wegscheider, G. Giedke and S. Ludwig: *Large nuclear spin polarization in gate-defined quantum dots using a single-domain nanomagnet;* Phys. Rev. Lett. 110, 177602 (2013).

B. Rühle, M. Davies, T. Bein and C. Bräuchle: *Fluorescence Microscopy Studies of Porous Silica Materials;* Z. Naturforsch. 68b, 423 (2013).

S. Rulands, B. Klünder and E. Frey: *Stability of localized wave fronts in bistable systems;* Phys. Rev. Lett. 110, 038102 (2013).

B. Sbierski, M. Hanl, A. Weichselbaum, H.E. Türeci, Moshe Goldstein, L.I. Glazmann, J. von Delft, and A. Imamoglu: *Proposed Rabi-Kondo Correlated State in a Laser-Driven Semiconductor Quantum Dot;* Phys. Rev. Lett. 111, 157402 (2013).

G.J. Schinner, J. Repp, K. Kowalik-Seidl, E. Schubert, M.P. Stallhofer, A.K. Rai, D. Reuter, A.D. Wieck, A.O. Govorov, A.W. Holleitner and J.P. Kotthaus: *Quantum Hall signatures of dipolar Mahan excitons;* Phys. Rev. B 87, 041303(R) (2013).

G.J. Schinner, J. Repp, E. Schubert, A.K. Rai, D. Reuter, A.D. Wieck, A.O. Govorov, A.W. Holleitner and J.P. Kotthaus: *Confinement and Interaction of Single Indirect Excitons in a Voltage-Controlled Trap Formed Inside Double InGaAs Quantum Wells;* Phys. Rev. Lett. 110, 127403 (2013).

G.J. Schinner, J. Repp, E. Schubert, A.K. Rai, D. Reuter, A.D. Wieck, A.O. Govorov, A.W. Holleitner and J.P. Kotthaus: *Many-body correlations of electrostatically trapped dipolar excitons;* Phys. Rev. B. 87, 205302 (2013).

J. J. Schmied, C. Forthmann, E. Pibiri, B. Lalkens, P. Nickels, T. Liedl and P. Tinnefeld: *DNA Origami Nanopillars as Standards for Three-dimensional Superresolution Microscopy;* Nano Letters 13, 781-785 (2013).

M.I. Schukfeh, K. Storm, A. Mahmoud, R. R. Søndergaard, A. Szwajca, A. Hansen, P. Hinze, T. Weimann, S. F. Svensson, A. Bora, K.A. Dick, C. Thelander, F.C. Krebs, P. Lugli, L. Samuelson and M. Tornow: *Conductance Enhancement of InAs/InP Heterostructure Nanowires by Surface Functionalization with Oligo-phenylenevinylenes;* ACS Nano 7, 4111–4118 (2013).

R. Schutjens, F.A. Dagga, D.J. Egger and F.K. Wilhelm: *Single-qubit gates in frequency-crowded transmon systems;* Phys. Rev. A 88, 052330 (2013).

K. Schwinghammer, B. Tuffy, M. B. Mesch, E. Wirnhier, C. Martineau, F. Taulelle, W. Schnick, J. Senker and B.V. Lotsch: *Triazine-based carbon nitrides for visible-light-driven hydrogen evolution;* Angew. Chem. Int. Ed. 52, 2435–2439 (2013).

S.A.I. Seidel, P.M. Dijkman, W.A. Lea, G. van den Bogaart, M. Jerabek-Willemsen, A. Lazic, J.S. Joseph, P. Srinivasan, P. Baaske, A. Simeonov, I. Katritch, F.A. Melo, J.E. Ladbury, G. Schreiber, A. Watts, D. Braun and S. Duhr: *Microscale thermophoresis quantifies biomolecular interactions under previously challenging conditions;* Methods 59, 301–315 (2013).

M. Sikor, K. Mapa, L. Voith von Voithenberg, D. Mokranjac, D.C. Lamb: *Real-time observation of the conformational dynamics of mitochondrial Hsp70 by spFRET;* EMBO J 32(11), 1639 (2013).

T. Sirtl, S. Schlögl, A. Rastgoo-Lahrood, J. Jelic, S. Neogi, M. Schmittel, W.M. Heckl, K. Reuter and M. Lackinger: *Control of Intermolecular Bonds by Deposition Rates at Room Temperature: Hydrogen Bonds Versus Metal Coordination in Trinitrile Monolayers;* J. Am. Chem. Soc. 135, 691 (2013).

T. Sirtl, W. Song, G. Eder, S. Neogi, M. Schmittel, W.M. Heckl and M. Lackinger: *Solvent-Dependent Stabilization of Metastable Monolayer Polymorphs at the Liquid–Solid Interface;* ACS Nano 7, 6711 (2013).

D.M. Smith, V.J. Schüller, C. Engst, J.O. Rädler and T. Liedl: *Nucleic acid nanostructures for biomedical applications;* Nanomedicine 8, 105-121 (2013).

S. Stapfner, L. Ost, D. Hunger, J. Reichel, I. Favero and E.M. Weig: *Cavity-enhanced optical detection of carbon nanotube Brownian motion;* Appl. Phys. Lett. 102, 151910 (2013).

C.V. Sumowski, M. Hanni, S. Schweizer and C. Ochsenfeld: *Sensitivity of Ab-Initio vs. Empirical Methods in Computing Structural Effects on NMR Chemical Shifts for the Example of Peptides;* J. Chem. Theory Comput. 10, 122 (2014).

F. Thüroff, C.A. Weber and E. Frey: *Critical Assessment of the Boltzmann Approach to Active Systems;* Phys. Rev. Lett. 111, 190601 (2013).

** CeNS Publication Award*

A.A. Torrano, J. Blechinger, C. Osseforth, C. Argyo, A. Reller, T. Bein, J. Michaelis and C. Bräuchle: *A fast analysis method to quantify nanoparticle uptake on a single cell level;* Nanomedicine 8(11), 1815 (2013).

A.A. Torrano, J. Blechinger and C. Bräuchle: *Trafficking and Intracellular Distribution of Nanoparticles* (Subchapter 6.4 of Chapter 6: "Biological Responses to Nanomaterials") *in*: Safety Aspects of Engineered Nanomaterials, Eds.: Luther W., Zweck A., Pan Stanford Publishing 175 (2013).

F. Trixler: *Quantum Tunnelling to the Origin and Evolution of Life;* Current Organic Chemistry 17(6), 1758 (2013).

F. Trixler: *Prebiotic Chemistry (Ed.);* Current Organic Chemistry 17(16) (2013).

C. Troiber, J.C. Kasper, S. Milani, M. Scheible, F. Schaubhut, S. Küchler, J. Rädler, F.C. Simmel, W. Friess and E. Wagner: *Comparison of four different particle sizing methods for siRNA polyplex characterization;* Eur J. Pharm. Biopharm. 84, 255–264 (2013).

C. Troiber, D. Edinger, P. Kos, L. Schreiner, R. Kläger, A. Herrmann, E. Wagner: *Stabilizing effect of tyrosine trimers on pDNA and siRNA polyplexes;* Biomaterials 34, 1624-1633 (2013).

B. Urbaszek, X. Marie, T. Amand, O. Krebs, P. Voisin, P. Maletinsky, A. Högele and A. Imamoglu: *Nuclear spin physics in quantum dots: an optical investigation;* Rev. Mod. Phys. 85 , 79-133 (2013).

S. Venkatesan, M. H. Madsen, H. Schmid, P. Krogstrup, E. Johnson and C. Scheu: *Direct observation of interface and nanoscale compositional modulation in ternary III-As heterostructure nanowires;* Appl Phys Lett 103, 063106 (2013).

A. Vetter, K.S. Virdi, S. Espenlaub, W. Rödl, E. Wagner, P.S. Holm, C. Scheu, F. Kreppel, C. Spitzweg and M. Ogris: *Adenoviral vectors coated with PAMAM dendrimer conjugates allow CAR independent virus uptake and targeting to the EGF receptor;* Mol Pharm 10 (2), 606 (2013).

O. Viehmann, J. von Delft, and F. Marquardt: *Observing the Nonequilibrium Dynamics of the Quantum Transverse-Field Ising Chain in Circuit QED;* Phys. Rev. Lett. 110, 030601 (2013).

K.S. Virdi, Y. Kauffmann, C. Ziegler, P. Ganter, B.V. Lotsch, W.D. Kaplan, P. Blaha, C. Scheu: *Electronic structure of $KCa_2Nb_3O_{10}$ as envisaged by density functional theory and valence electron energy loss spectroscopy;* Phys Rev B 87, 115108 (2013).

S.K. Vogel, Z. Petrasek, F. Heinemann and P. Schwille: *Myosin motors fragment and compact membrane-bound actin filaments;* eLife, 2:e00116 (2013).

C.A. Weber, T. Hanke, J. Deseigne, S. Léonard, O. Dauchot, E. Frey and H. Chaté: *Long-range ordering of vibrated polar disks;* Phys. Rev. Lett. 110, 208001 (2013).

C. Westermeier, M. Fiebig and B. Nickel: *Mapping of Trap Densities and Hotspots in Pentacene Thin-Film Transistors by Frequency-Resolved Scanning Photoresponse Microscopy;* Advanced Materials 25(40), 5719–5724 (2013).

U. Wienken and H.E. Gaub: *Stamping Vital Cells—a Force-Based Ligand Receptor Assay;* Biophysical Journal 105(12), 2687-2694 (2013).

A. S. Wochnik, M. Handloser, D. Durach, A. Hartschuh and C. Scheu: *Increasing crystallinity for improved electrical conductivity of TiO_2 blocking layers;* ACS Appl Mater Interfaces 5 (12), 5696 (2013).

C. Ziegler, S. Werner, M. Bugnet, M. Woersching, V. Duppel, G.A. Botton, C. Scheu and B.V. Lotsch: *Artificial solids by design: assembly and electron microscopy study of nanosheet-derived heterostructures;* Chem Mater 25(24), 4892 (2013).

K. Zieske and P. Schwille: *Reconstitution of Pole-to-Pole Oscillations of Min Proteins in Microengineered Polydimethylsiloxane Compartments;* Angew Chem Int Ed Engl. 52, 459-462 (2013).

THESES

MASTER'S & DIPLOMA THESES

Andreas Beil: *Synthese modifizierter siRNAs zur Beeinflussung von Immun- und Stammzellen* (LMU, T. Carell); **Sebastian Berchtold:** *DMRG Methods for Finite Temperatures* (LMU, U. Schollwöck); **Silke Bergeler:** *Active Turing Systems* (LMU, E. Frey); **Antje Birkner:** *Super-resolution two-photon microscopy in the living brain* (LMU, J. Rädler); **Michael Blum:** *Applicability of the Solid/Solid- Wetting Concept on Graphenes: Examination of Substrates and Organic Semiconductor Adsorbates* (Hochschule München, U. Menczigar, A. Kersch & F. Trixler); **Philip Böhm:** *Untersuchung der Diffusion von DNA-Nanostrukturen auf substratgestützten Lipidschichten* (LMU, T. Liedl); **Dario Brack:** *Electron microscopy and single particle image processing on myosin-XXI* (LMU, C. Veigel & H. Gaub); **Victor Albert Brantl:** *Etablierung einer neuen LC-MS basierten Quantifizierungsmethode für abasische Stellen in genomischer DNA* (LMU, T. 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Fabian Heidrich-Meisner: *Many-body physics with low-dimensional ultra-cold atomic gases: Fermionic superfluids and non-equilibrium dynamics* (LMU, U. Schollwöck)

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