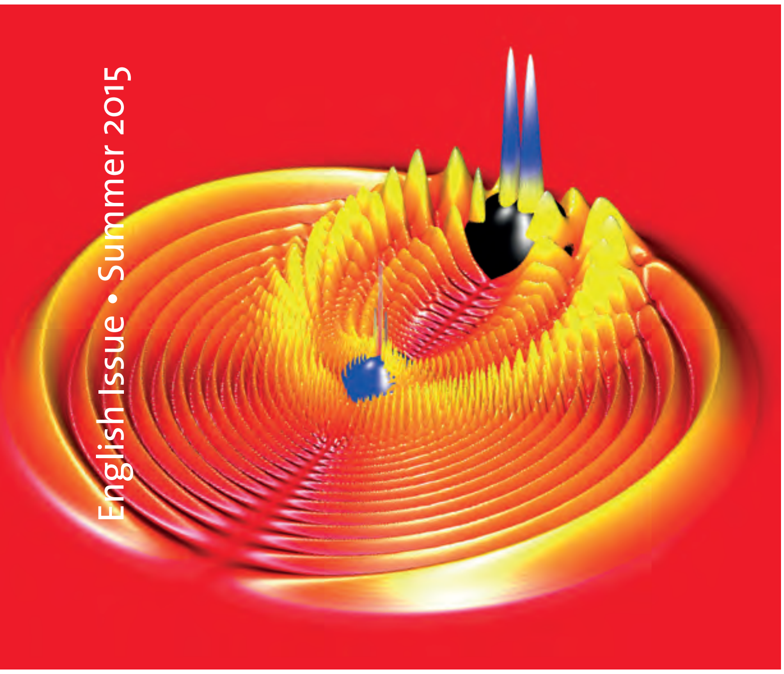
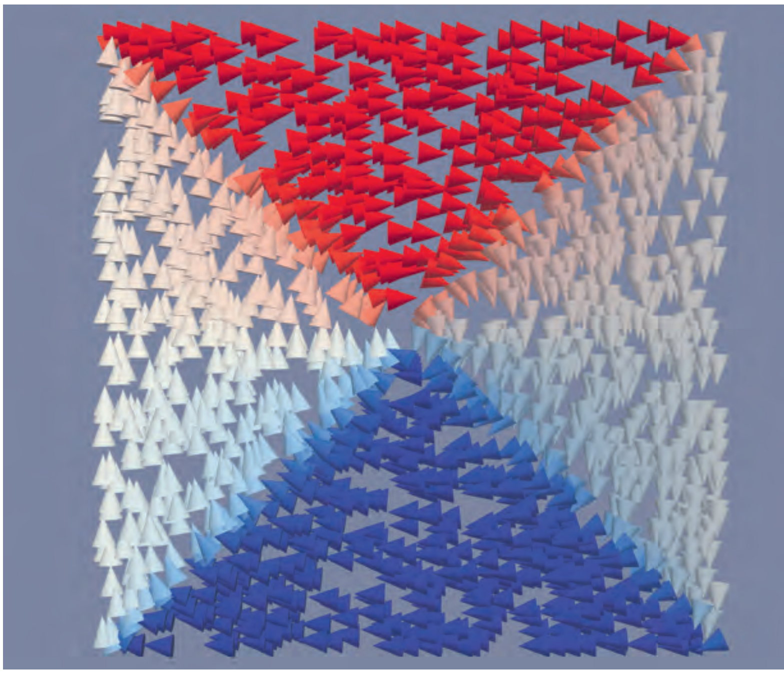
BRIGHT & VISIONARY

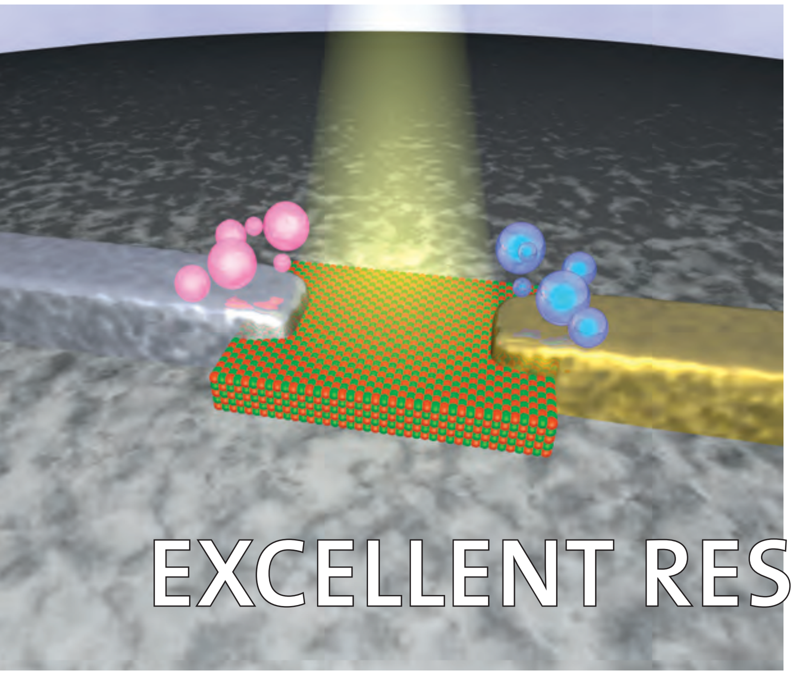
CUI NEWS

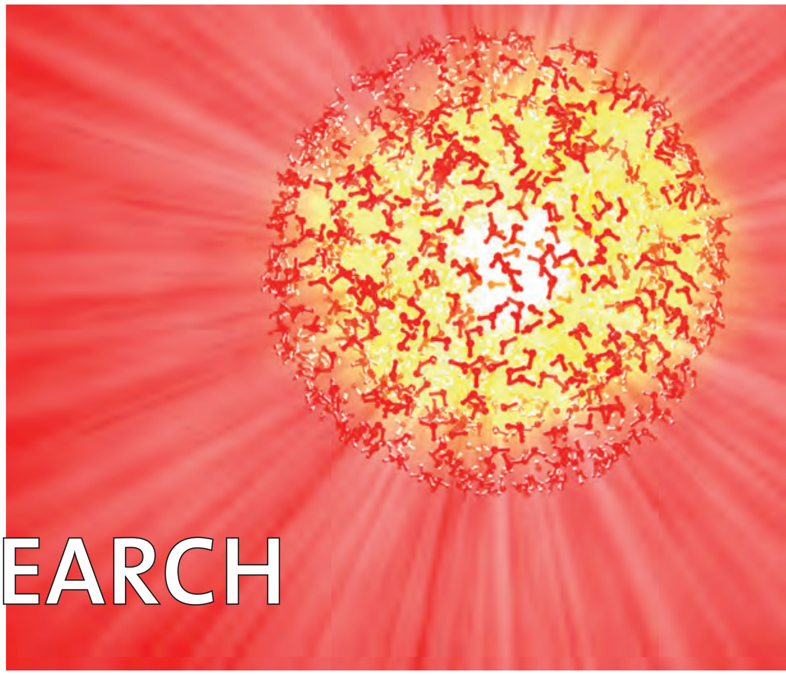
INSIGHTS INTO THE HAMBURG CENTRE FOR ULTRAFAST IMAGING

English Issue • Summer 2015









EXCELLENT RESEARCH

ULTRAFAST DYNAMICS

How do particles move and why do we want to know?

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WOMEN AS ROLE MODELS

Mildred Dresselhaus Award has long lasting effects on career and co-operations

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NEW PROFESSORS

Hamburg offers excellent research and career opportunities

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Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

CUI THE HAMBURG CENTRE FOR ULTRAFAST IMAGING

Dear reader!

We are very pleased to present to you the first English issue of our CUI News as a compact version of the previous four German issues. A lot has happened since our cluster of excellence got started on 1 November 2012. Colleagues from Universität Hamburg, DESY, the Max Planck Institute for the Structure and Dynamics of Matter, the European XFEL GmbH, and the European Molecular Biology Laboratory have been working together to solve some of the greatest and most exciting challenges of contemporary science: Observing and understanding the ultrafast dynamics of atoms, molecules and electrons, so that maybe, one day, we will be able to control them systematically.

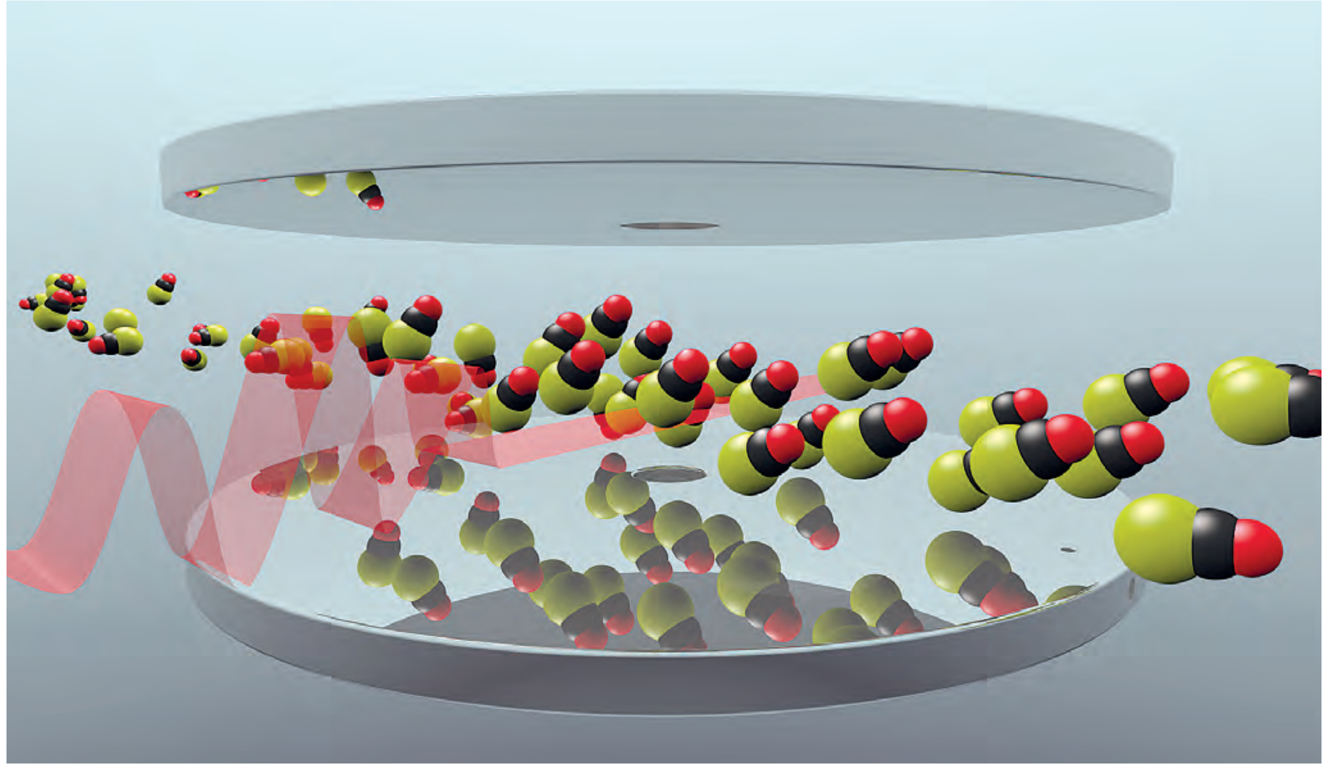
By now, half of the project phase is over, and we are happy to say that the members of CUI have achieved excellent results. These, among others, are represented in a long list of publications on our webpage www.cui.uni-hamburg.de/en. In addition, the two and a half years were marked by exciting pioneering work: Appointing six new professors, building up new working groups, equipping new laboratories, and developing new methods. Looking at all the excellent results, we are convinced that we have set a good course for the research in our field and that we will continue doing so.

We received great news when we were told that the German excellence initiative will be continued after 2017. In parallel with the political developments, the members of CUI are discussing the future of our cluster. We are looking forward to a next excellence initiative and we will apply with a new concept that we are currently developing.

In this issue of our CUI News we would like to give you an overview of the three research areas including possible applications. Moreover, you will find what international PhD students think about life in Hamburg and why scientists returned from abroad to become a professor at CUI. We also asked our first Mildred Dresselhaus Awardee to reflect on the impact the prize has on her career. Last but not least we are very proud that our school lab keeps succeeding in developing new projects to excite young people about natural sciences.

Enjoy reading!

Prof. Dr. Klaus Sengstock
Prof. Dr. Horst Weller
Prof. Dr. R. J. Dwayne Miller
CUI spokespersons



The illustration (left) from Jens S. Kienitz (CFEL, DESY) shows the alignment of molecules with light. A strong laser field (red) forces randomly oriented free molecules into a preferred direction (Fig. 1).

A RESEARCH REPORT FROM RESEARCH AREA A – „IMAGING AND CONTROL OF QUANTUM SYSTEMS“

QUANTUM PHYSICS ILLUSTRATES FUNDAMENTAL PROCESSES OF NATURE

Strictly speaking, all objects in the universe are "quantum systems". Ultimately, all natural processes obey the laws of quantum physics. Although many larger systems can often be described in a classical way which is not based on quantum theory, research area A particularly focuses on the phenomena beyond classical physics. The scientists of this research area want to make fundamental processes of nature observable, display their development with time resolution and gain control over these systems with the help of light.

Representatives of these quantum systems are single atoms. The electrons of these atoms move on clearly defined paths – or more correctly quantum-mechanically– on clearly defined orbitals. Their dynamic changes are made visible particularly by their interaction with light. When irradiating the atoms with X-ray light, the enormous intensity provided by free-electron lasers makes it possible that a single atom absorbs many photons within a very short time. At the same time, many electrons are knocked out of the atomic shell, followed by a complicated cascade of subsequent processes. The observation of these processes provides information on the interaction of elementary quantum particles – the electrons – in the force field of a highly-charged ion.

Research, however, does not only focus on single atoms. With appropriate cooling, many (one million or more) atoms can form a joint macroscopic quantum state, a "Bose-Einstein condensate (BEC)". These ultra cold quantum gases can then be highly excited by the absorption of thousands of photons as well. After this excitation, a collaborative team in the CUI investigates if and how the system, on a time-scale of micro- to milliseconds, finds its way back into its original BEC-state.

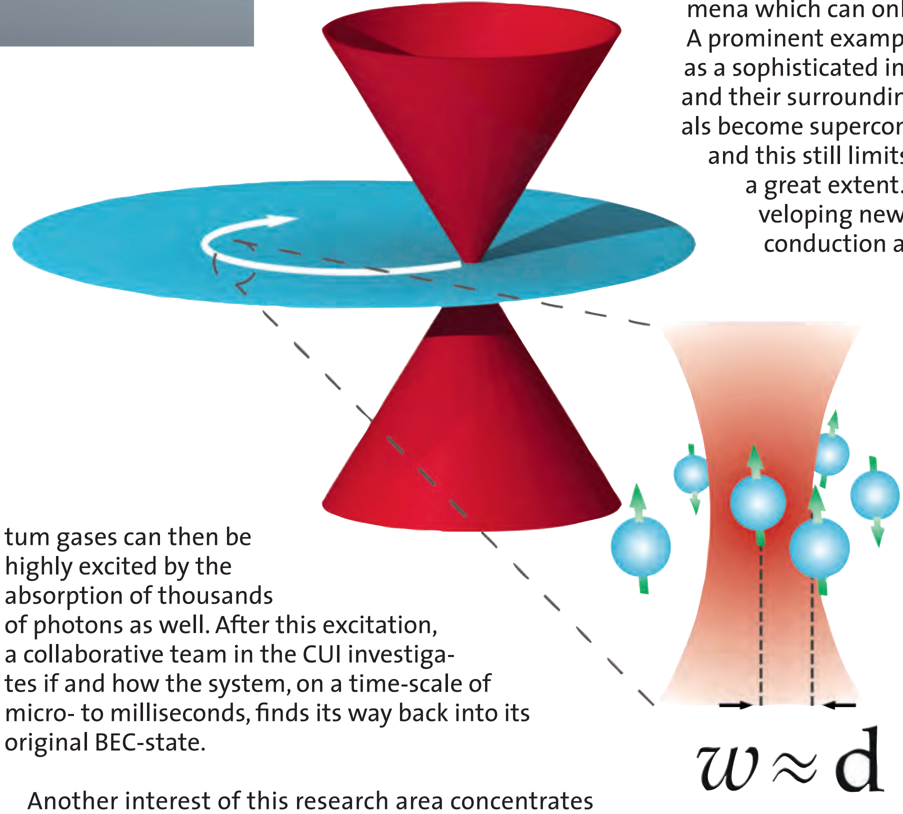


Illustration (below) on the investigation of superfluidity carried out by the group headed by Professor Henning Moritz and Professor Ludwig Mathey (Universität Hamburg): With a laser beam (red) a cloud of ultra-cold atoms (blue) is stirred circularly, similar to a spoon in a mug of coffee. In this process it is shown that the cloud of atoms flows around the moving obstacle without friction and – unlike coffee – is not set into rotation (Fig. 2).

Another interest of this research area concentrates on molecules: In molecules, the dynamics of electron movement is still linked to the – slower – movement of atomic nuclei. Here, the goal is to track the change of chemical bonds in real-time, i.e. with the necessary time-resolution of 10^{-14} seconds, finding methods to control molecular processes with the help of light fields. For this purpose, the molecules are again put into an electronically excited state with laser pulses within a very short period of time. The scientists of the research area have invented new methods of excitation. For example, the solvent bath is heated within picoseconds by using terahertz pulses. The time-delayed detection of an excited transition state with X-ray pulses allows for a high chemical selectivity because it makes it possible to select the absorption edges of individual chemical elements within the molecule.

Moreover, static and dynamic electrical fields can be used to align the molecules in space (Fig. 1). This is especially important for the investigation of chemical reactions which almost always depend on the relative alignment of the reaction partner involved. For the excitation, detection and orientation of molecules, short light pulses are needed not only in the visible and ultraviolet but also in the X-ray and terahertz spectral range. Therefore, the scientists use the state-of-the-art X-ray radiation sources available in Hamburg, such as the electron storage ring PETRA III and the free-electron laser FLASH at DESY and, before long, the free-electron laser European XFEL. Simultaneously, new laser sources are being developed with an extended frequency range, shorter pulse duration and improved synchronization (see article about spin-off, p. 6). Equally as important as the improvement of the optical sources is the further improvement of the theoretical tools. These enable a more and more realistic modelling and precise prediction of time-dependent quantum physics phenomena.

Even extended solids show certain macroscopic phenomena which can only be explained by quantum physics. A prominent example is superconductivity. It is interpreted as a sophisticated interaction between paired electrons and their surrounding solid state lattice. Common materials become superconductive only at very low temperatures and this still limits large-scale technical applications to a great extent. Hence, there is a major interest in developing new materials offering a loss-free electric conduction at room temperature. With intensive light fields, it is already possible, at least for short periods of time, to make materials superconductive even at room temperature.

Because of the quantum nature of superconductivity, it is very difficult to simulate this phenomenon with classical computers. At this point, the ultra-cold quantum gases come into play again. The ultra-cold atoms are trapped in a three-dimensional periodic force field shaped by superimposed light fields, forming a solid state lattice. This creates a "quantum simulator" which allows one to reproduce the behavior of real materials. Since such a simulator can be perfectly controlled, it is ideally suited for studying the influence of different parameters on the investigated quantum phenomenon, free of interference.

A macroscopic quantum phenomenon which is closely related to superconductivity is superfluidity: A fluid under certain circumstances does not offer any resistance to an object which is stirred in it. CUI scientists were able to show that this kind of superfluidity could also be realized in ultra cold quantum gases (Fig. 2). ■

Professor Andreas Hemmerich emphasizes the importance of independent basic research, irrespective of applications

CURIOSITY IS THE SOURCE OF BASIC RESEARCH AND INDEPENDENCE ITS PRECONDITION

Non-specialists often have trouble understanding basic research. Moreover, it frequently happens that 20 years go by between a research result and its openly visible application. We interviewed Professor Andreas Hemmerich, head of the „Atom Optics Group" at the Institute of Laser Physics (ILP) of Universität Hamburg, about his understanding of basic research and its importance to society. Hemmerich does research in the CUI research area A „Imaging and Control of Quantum Systems" which is subdivided into two large groups of themes: quantum dynamics in atomic and molecular systems, and correlated many-body systems.

Professor Hemmerich, what is the importance of basic research?

Prof. Hemmerich: First of all, it is important to understand that novel basic research usually does not originate from the desire to realize particular applications. It has to be seen as a cultural achievement; its source being curiosity and independence its precondition. Application is certainly what society justly expects from research, but the desire for applications is not the appropriate steering instrument to undertake basic research. This is due to the fact that we usually do not know today which applications might be important tomorrow. Of course, there are certain problems of social significance, such as combatting of major diseases, or energy and climate themes. In this respect, it is obvious that strategy-oriented and substantially controlled research is reasonable. As a general rule, however, this is not the formula to generate excellent research.

What is necessary to make basic research a success?

Prof. Hemmerich: Independence! Society must give space for creative minds to pursue their curiosity. It must also be possible to do research for a while in such directions which are not characterized from the outset by a strong social relevance. At the beginning of a scientific career, we certainly need high entry barriers and competition, such as appointment procedures which very earnestly assess the originality of applicants instead of comparing their h-indices. After this, however, a credit of trust is needed in giving the scientists the choice to swim against the tide. This requires a lot of patience. 95 percent of the research results will be forgotten after five years, but the remaining five percent have a lot to offer, yet their significance is sometimes revealed only after 25 years.

Could you give us an example from your field of research?

Prof. Hemmerich: The invention of the laser is a perfect example. The first maser, a kind of microwave laser, was presented at the beginning of the 1950s. It was developed on the basis of the war-relevant radar technology which was pushed forward in the 1940s. At the beginning of the 1960s, the first laser with optical frequencies was realized, but only a small group of specialists responded. The general opinion was that this was a version of the maser with an undefined application potential. Only in the 1980s there was a major breakthrough with semiconductor lasers for consumer electronics and telecommunication. In the 1960s, no one would have imagined that this development was possible. Research which takes place today should not exclusively be judged by the criteria of already visible applications. Experience clearly shows that basic research driven by curiosity pays off in the long run. In this case, we can learn from the self-assuredness of the large US universities.

What is different in the United States?

Prof. Hemmerich: In Germany, in the past ten years, we have witnessed the increasing importance of collaborative project funding. The idea is that large project collaborations with an interdisciplinary and a thematically coordinated profile carry out the best research. In both countries, Germany and the United States, collaborative project funding is prevalent; in my field of research for example, scientists from Harvard University and MIT are doing joint research in the Center for Ultracold Atoms (CUA). There too, curiosity is predominant and the ideas of individual scientists are at the focus of the project. A strategic guiding principle is nowhere to be found. The teams are relatively small; instead of a pyramidal structure for large groups, you will find flat hierarchies where even professors operate close to research and there are lean administrative structures. Despite all the criticism, I want to state very clearly that, thanks to the German Research Foundation, basic research in Germany has a good position compared to international standards.

Which type of science policy is needed for basic research?

Prof. Hemmerich: It is very important that science policy acts carefully, without continuously issuing new strategic guidelines and with a well developed sense of quality. A good science policy must guarantee independence to try out something new. At the same time, it must include a conservative aspect: the recognition and growth of the established quality. Two good examples are the ILP (Institute of Laser Physics) and the ZOQ (Center for Optical Quantum Technologies). Within a period of ten years, these institutions achieved global visibility and attraction. These successful structures do not develop in just one day and they should not be sacrificed carelessly to politically motivated structure visions.

Do you also see a connection between basic research and cultural or social developments?

Prof. Hemmerich: The example of laser research with its impact on information and consumer industries very clearly shows the strong influence of technology-related research results. However, there is another very important aspect. In the field of basic research, many young people get an extremely good professional training. They are in the midst of activities when something completely new is developed – there is no better training. It is not without reason that our doctoral students are selling like hot cakes and earn a lot of money in business and industry. These young people bring along an important asset: They feel well working at places where there is still no structure and where something completely new can be devised and developed. Industry in Germany can make good use of this spirit.

What is your own motivation?

Prof. Hemmerich: Curiosity to begin with. My research field "ultracold quantum gases" has a particularly high degree of aesthetics. Sophisticated modern precision technology is combined with the intellectually appealing and profound concepts of many-body quantum physics. But I am also interested in a culture that promotes spin-offs. Our lasers are so special that we have a foothold in laser development as well. In Munich, for example, I developed a small semiconductor laser system with my students, which was supported by an industrial partner. However, nobody in that team wanted to leave basic research so we outsourced this commercialization project. This developed into the launch of the very successful TOPTICA Photonics AG. I think that the existence of this spin-off culture is very important. But how does one promote this? The universities doing research driven by curiosity definitely play a central role; they are beacons which attract many clever minds. Next, a non-bureaucratic possibility to develop prototypes, for example in the course of doctoral studies or after graduation, is needed. Then, if easily accessible spin-off support is provided, this will work out.

Thank you very much for this interview. ■

Ad personam

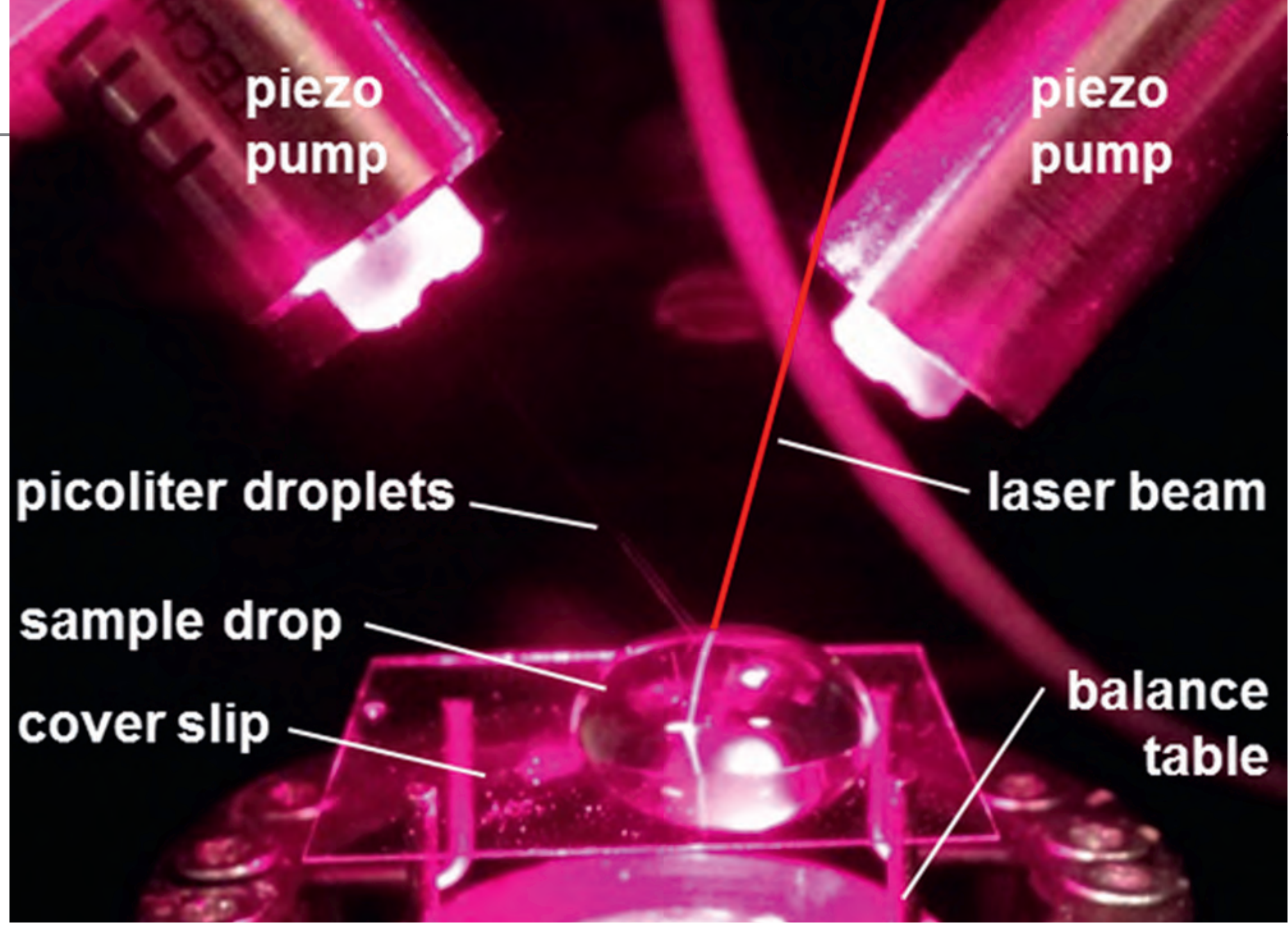
Prof. Dr. Andreas Hemmerich received his doctoral degree in 1990 at the Max-Planck-Institute of Quantum Physics in Munich. He then built up a cold atom research team at the University of Munich, which in 1992 was the first to trap atoms in two- and three dimensional optical lattices. After his habilitation in 1995, he followed a call at the newly founded Institute of Laser Physics (ILP) at Universität Hamburg and headed the Institute from 1999 to 2003. During that time period he devoted much attention to the construction planning of a modern research building. His research is concerned with the physics of ultracold quantum gases. Together with his team, he recently reported the first observations of chiral superfluidity in higher band of optical lattices.

Spin-off Cycle GmbH: ultra-precise optical synchronization system

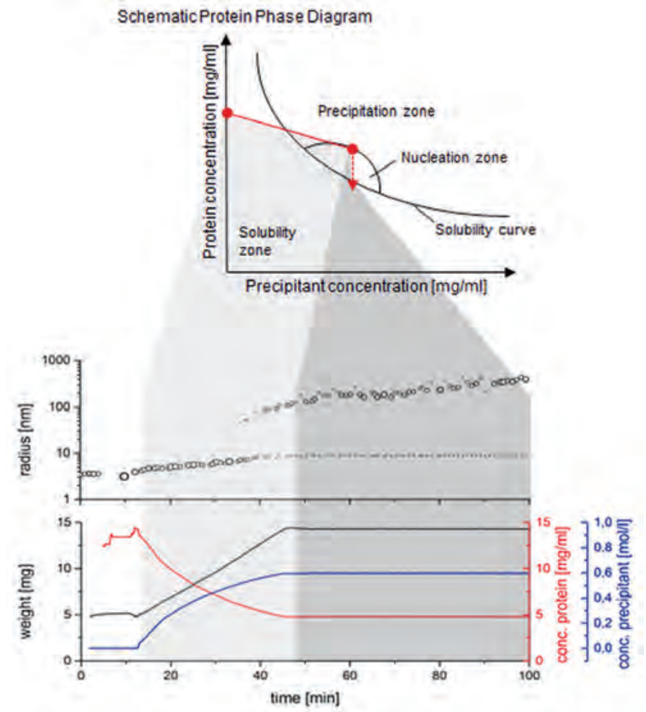
The longtime research work in the Ultrafast Optics and X-ray Division of CUI scientist Professor Franz X. Kärtner (DESY, CFEL, MIT) gave rise to a company foundation: Under the management of Dr. Damian N. Barre (CFEL), Cycle GmbH went into business.

The company develops and produces timing distribution systems based on fiber optic cables and ultrashort pulse laser technology. The special feature of these systems is that they allow the synchronization of a number of optical and microwave instruments across several kilometers with the precision of one femtosecond, i.e. the millionth of a billionth of a second. These unique features are of vital importance for the synchronization of large-scale measuring facilities, such as free-electron laser accelerator facilities, radar stations or radio telescopes. In fact, external influences such as temperature changes cause alterations in the length of a several hundred-meters long cables of large-scale research facilities and temporal shifts of signals. In order to stabilize the facility against these influences, a synchronization system is required which is more powerful than the standard systems based on RF signals and metallic microwave cables. The task of the synchronization system can be compared to the job of an orchestra conductor. Only the setting of the precise pulse allows a synchronized interaction of instruments in the large-scale measuring facility.

Such a precise synchronization is of crucial importance for research with pump-probe techniques at large-scale facilities, such as the European XFEL. With these facilities it is possible to film ultrafast processes, enabling the investigation of forms of matter under extreme conditions. It allows one to decode the structure and function of medically important molecules – giving significant information for the development of new medication for so far incurable diseases such as Alzheimer's or cancer. Additional fields of application of these free-electron lasers which include this new synchronization method are the development of new fuels based on artificial photosynthesis and the investigation of catalysts for a sustainable chemical industry. In the medium run, the company will extend its product range with innovative and reliable ultrashort pulse lasers for scientific and industrial applications.
At CUI, Franz Kärtner participates in projects on photo-driven chemical dynamics in the sub-femtosecond range. He and his group develop new optical methods to investigate and control charge transfer dynamics on surfaces.
> www.cyclelasers.com



The Xtalcontroller allows the characterizing and active control of time-dependent crystallization processes by the growth of crystallization seeds



Xtalcontroller setup for the targeted control of crystallization processes

A RESEARCH REPORT FROM RESEARCH AREA B „ATOMICALLY RESOLVED STRUCTURAL DYNAMICS“

SETTING THE FOCUS ON BIOLOGICAL PROCESSES: NEW METHODOLOGY TO CREATE AND CHARACTERIZE PROTEIN NANOCRYSTALS

Current CUI research results impressively proved the unique potential of X-ray lasers for decoding proteins and other macromolecular biomolecules. Already now, it has become evident that the avoidance of radiation-induced damage of the samples, analyses at room temperature and the possibility of investigating microscopic protein crystals will have an enormous impact on future structural biology. In this context, diffraction data collection at room temperature is particularly advantageous to observe time-resolved biological processes.

Today, structure determination with free-electron X-ray lasers (FELs) is based on the method of serial femtosecond crystallography (SFX), chiefly developed by the research group of Professor Henry Chapman (Universität Hamburg, DESY). Compared to conventional methods, the diffraction data in this case are taken not just from one or a few crystals within the millimeter size range, but from several hundred thousand crystals with nanometer dimensions at room temperature. With the extremely high intensity of the X-ray pulses of 2-3 mJ/pulse and a pulse length of about 50 femtoseconds, it is possible to take diffraction images of each nanocrystal individually, before the sample is completely destroyed.

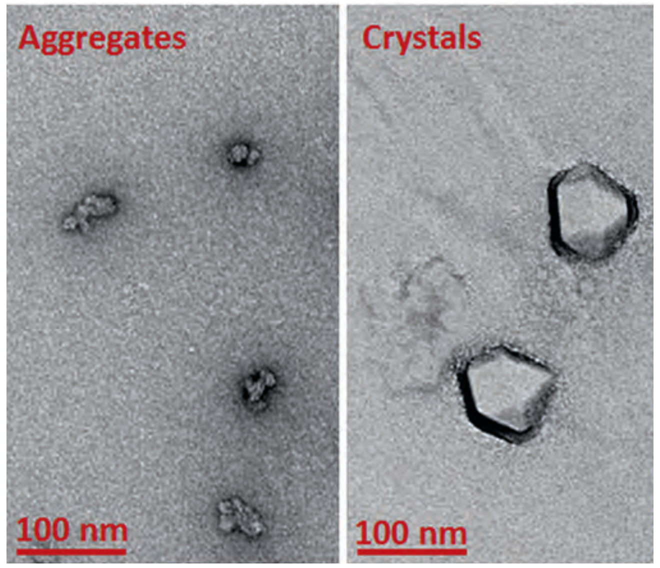
The SFX method needs one crystal for each single diffraction image. For this purpose, microscopically small crystals with a volume of about 1-2 µm³, in a fine liquid jet with a diameter of 3-4 µm, are fed into the FEL X-ray beam at room temperature. Growing nano- and microcrystals from proteins which are difficult to crystallize and which do not allow data collection with conventional methods is required for the use of the SFX methodology.

Within the framework of a cooperation project, CUI scientists of research area B were able to show, with a modified experimental set-up, that serial crystallography on microcrystals can also be successfully utilized for structure determination by using a highly intense X-ray beam at the PETRA III synchrotron radiation facility. This new method was recently presented in the Journal of the International Union of Crystallography (IUCrJ, 2014, 1, 87-94).

In the field of controlling and monitoring crystallization processes of macromolecular biomolecules, another research area B group headed by Professor Christian Betzel also contributed very promising results. With a newly developed method, the crystallization process can be dynamically influenced and optimized in that way that it is possible to create crystals of a defined size. This new system is now further developed in cooperation with a Hamburg-based spin-off firm.

In the process of crystallization, the biomolecules to be crystallized undergo different phases of state which in this system are continually observed and characterized by dynamic laser light scattering (DLS). For a successful and targeted crystallization, the knowledge and characterization of these processes, which depend on concentration and time, are of fundamental importance: Each crystallization process is individually and actively influenced, dependent on the phases of state. The detection of first nucleation seeds is particularly important for the further success of crystallization. These seeds cannot be visualized by conventional light- or electron-microscopic procedures.

CUI scientists were able to identify a DLS “fingerprint” which is characteristic for the successful growth of nanocrystals with a size of 50 nm to 300 nm. For the identification of these fingerprints; after the experiments, several samples were examined with transmission electron microscopy. The corresponding findings confirm that – with the radius distributions of the particles in the crystallization process obtained by DLS - it is possible to distinguish between non-crystalline protein aggregates or protein nanocrystals, even when both have a similar size. In the future, this will allow us to make a reliable statement on the state of the crystallization process and, therefore, to produce protein crystals much more efficiently and targeted for structural analysis at free-electron lasers and highly intensive synchrotron radiation sources. ■



Electron-microscopic images of non-crystalline protein aggregates (left) and nanocrystals (right) with a size of less than 100 nanometers. The Xtalcontroller allows us to distinguish during the growth process

Unique combination of research fields

Research area B is characterized by a multidisciplinary expertise in the research fields of laser physics, structural biology, chemistry, molecular physics and infection biology – a combination which is unique in Hamburg.

Scientists from Universität Hamburg, the university hospital Universitätskrankenhaus Hamburg-Eppendorf (UKE), the Max Planck Society, the European Molecular Biology Laboratory (EMBL), European XFEL GmbH and Deutsches Elektronen-Synchrotron (DESY) collaborate to make atomic motions in complex systems visible.

Coherent imaging allows the direct observation of atomic motions. Application examples range from model systems of small molecules and single amino acids up to large protein complexes and molecular machines.

The scientists’ declared common goal is to investigate the dynamics and time-dependent processes of macromolecular functions.

The sample is inserted into the super X-ray laser LCLS at the US accelerator center SLAC.

Great joy in Professor Henry Chapman's workgroup at SLAC: For the first time, the scientists were able to observe diffraction patterns from tiny crystals

BATTLE AGAINST SLEEPING DISEASE

BEGINNING OF A REVOLUTION IN STRUCTURAL BIOLOGY

In an interview with CUI News Professor Henry Chapman talks about his research and explains why Hamburg is a very attractive location

A global research team, including CUI scientist Professor Henry Chapman (Universität Hamburg, DESY) developed and used a revolutionary new approach to analyze a protein of the parasite that causes African sleeping disease. Using the super X-ray laser LCLS at the US accelerator center SLAC, the scientists were able to determine the molecular structure of the cathepsin B enzyme in Trypanosoma brucei. As the parasite cannot survive without this enzyme, it is one of the candidates to target to develop a drug against sleeping sickness. The combination of protein crystallography using intense X-ray laser pulses with a new approach to obtain tiny protein crystals directly in living cells could be transformative for structural biology, providing new capabilities for many areas such as research for the pharmaceutical industry. Already now the interest in the new technique is growing in the structural biology community, with demand for beamtime that far exceeds what is currently available.

Professor Chapman, you made an outstanding contribution to fight sleeping disease. How does a physicist come to do this?
Prof. Chapman: Honestly, I do not know much about biology. However, as a physicist, I have been developing new ways to form images of macromolecular structures. For our first demonstrations at LCLS, I was searching for very small crystals that might be suitable to explore the limits of our techniques. I therefore asked my colleague Christian Betzel if he knew anyone who had tiny protein crystals that couldn't be grown larger. As it happened, his collaborators had recently discovered crystals of the enzyme cathepsin B growing in the cells where the protein was expressed. Although such in vivo crystals had sometimes been seen before, they are limited in size because a cell is small. Christian had tried conventional analysis using synchrotron radiation but they were simply too small.

How exactly do these methods work?
Prof. Chapman: Generally, we use crystals of macromolecules to determine their structures using X-rays. When you shine an X-ray beam on a crystal you get an intricate pattern of spots. This "diffraction pattern" encodes the molecular structure, which can be unraveled with powerful computational techniques. But the problem is in measuring the diffraction. Since X-rays are ionizing they destroy the object we are trying to analyze. It is like trying to read a secret message on light sensitive paper. You need light to read the message, but as soon as you turn on the light the message fades away. Usually, protein crystals can only withstand a certain tolerable exposure, so the only way to measure the pattern had been with a big crystal that gives a strong pattern within that limited exposure. Our new advance is that with an intense X-ray flash from an X-ray laser like LCLS we can obtain strong diffraction from a small crystal before it is vaporized by the bright pulse. So then to obtain the full complement of three-dimensional data we record many flash diffraction patterns, each from a new fresh crystal that we inject continuously as a stream into the beam. At the LCLS, we managed to create 120 diffraction patterns per second and at the end, we obtained 175,000 patterns for calculation. In total, the amount of data we collected for the experiment would fit on more than 10,000 DVD's.

Thus, a discovery by coincidence at the beginning led to these experiments, which are extremely important for structural analysis and possibly also for drug development?
Chapman: Yes, there was indeed coincidence and some luck at the beginning. In research, as in life, we are always trying out something new. Actually, the whole story begins much earlier, when years ago we discussed about how to use free-electron lasers for structural analysis. Already as a post-doc, I worked with David Sayre, a prominent crystallographer, who promoted the idea of applying crystallographic analysis techniques to any general object, using a computer algorithm in place of a microscope lens. Later, I participated in the design and planning of the LCLS and we developed the idea of serial femtosecond crystallography and diffractive imaging. In 2005, we demonstrated single-shot X-ray imaging using DESY's FLASH in Hamburg and proved that we were able to create images before the beam destroys the sample. It wasn't until we were able to do measurements at the LCLS that we showed that our method extends to imaging at the atomic level.

And then, you decided for Hamburg as a good location for research?
Prof. Chapman: At that time, many scientists were still very skeptical about our ideas. In Hamburg, however, there was much support. With the planning of the CFEL (note: Center for Free-Electron Laser Science) I thought this location to be very attractive, because of the idea of bringing together world-class groups in a very collaborative atmosphere, close to the unique new facilities where we could realize our visions.

Talking about visions: Can you virtually get a fingerprint of the protein by the work with crystals?
Prof. Chapman: There is no formula for obtaining crystals of a specific protein. It is always trial and error and can often take years to find the right conditions. But many structural biologists obtain tiny crystals that had never been considered to be useful. At our first experiment with small crystals, we got a beautiful pattern and suddenly had a million diffraction images at our disposal. Then we only had to develop software to evaluate these, which combines the diffraction images in a way that allows the structure to be obtained.

Small crystals are much more universal than had previously been thought. With our technique they offer the opportunity to solve structures, which in earlier times were regarded as inaccessible, thus gaining insight about functions. Structural analysis is a central element of biology, but currently only about 100,000 structures have been determined (and are deposited in the protein database). Until now there was a real bottleneck in structural biology, which is the need to grow large well-diffracting crystals.

Professor Henry Chapman did research in the United States for a total of 16 years and, since 2007, is a professor at Universität Hamburg and head of the "Coherent Imaging" group (CFEL, DESY). The pioneer of research with free-electron lasers studied physics in Australia. The photograph shows him at the winterly Clifton Beach, Tasmania, with Mount Wellington in the background – the mountain Charles Darwin climbed in 1836 during his voyage with the Beagle

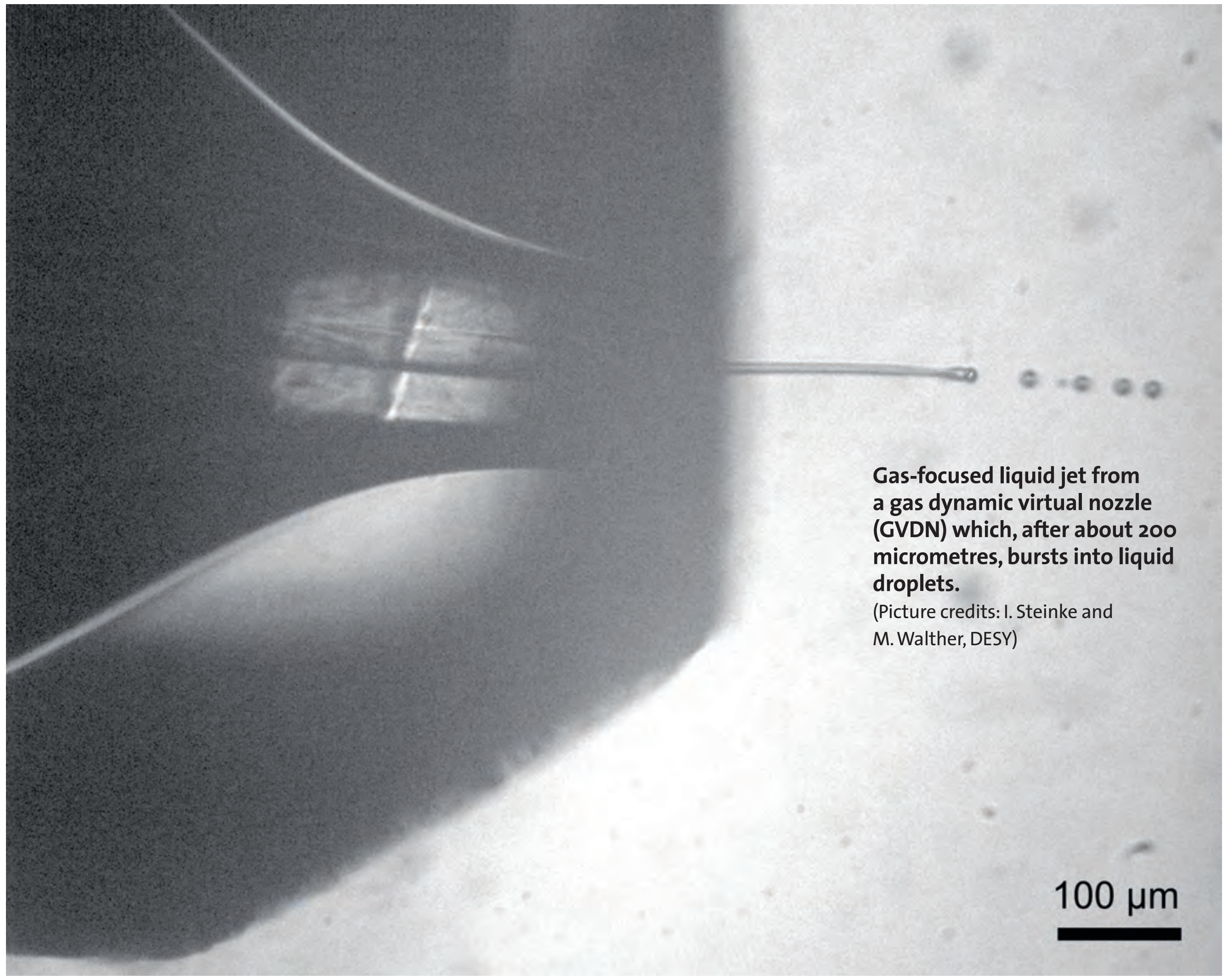
How do the dynamics come into play?
Prof. Chapman: The dynamics come into play very naturally when we observe reactions to understand the functioning of proteins. The reaction needs to be triggered by some means at a very definite time before the arrival of the X-ray pulse. The easiest way to do this is with an optical laser pulse, which of course works well for photoactive proteins. With our method, there are always fresh samples available, and we are not forced to restore the samples to their original state. In a FEL, you can view irreversible reactions very well.

And what is going to happen next?
Prof. Chapman: We want to revolutionize this field. Now, it is our dream to work with ever smaller crystals, perhaps all the way down to the single molecule. For this purpose, we must reduce the noise and unwanted signals in the detector and increase the intensity on the sample. We are improving methods to introduce particles into the X-ray focus with as little extra material that would otherwise contaminate the diffraction signal. Working with the smallest samples is challenging and will require many more collected diffraction patterns. At the LCLS, we would need about one month to collect the necessary data – at the European XFEL, this would take only a couple of hours because that facility will provide many more pulses per second. Therefore, our hopes are pinned on the completion of the XFEL. (Note: the European XFEL which is currently under construction is an X-ray laser running from Hamburg to Schenefeld in Schleswig-Holstein.) The European XFEL will also be transformative for serial crystallography too. We just recently established a SFX Consortium, to build an instrument particularly for these experiments. This will increase the accessibility to this new method tremendously, which is currently holding back development of the entire field.

Thank you very much for this interview. ■

Effective treatment of the deathly pathogen remains difficult

African sleeping sickness is a serious infectious disease transmitted by the tsetse fly and which, without treatment, is almost always lethal. According to the World Health Organisation (WHO), this infectious disease currently spreads over 36 African countries – in a region south of the Sahara inhabited by around 70 million people. In the past, severe epidemics occurred time and again. In some villages, up to 50 percent of the inhabitants fell ill. In 98 percent of the cases, the pathogen Trypanosoma brucei gambiense is responsible for the serious infectious disease. Diagnosis and treatment are extremely complex; without treatment, the sleeping sickness is almost always lethal. The disease develops in three stages: The first stage comes along with fever, itching and pains in the head and limbs. In the second stage, the parasite crosses the blood-brain barrier, causing behavioral changes, confusion, coordination and sleep disorders. In the final stage, the patient falls into a sleepy and semi-conscious state which gave the disease its name.



Gas-focused liquid jet from a gas dynamic virtual nozzle (GVDN) which, after about 200 micrometres, bursts into liquid droplets.
(Picture credits: I. Steinke and M. Walther, DESY)

A research report from research area C – „Dynamics in Nanostructures“

DYNAMICS AND ORDER FORMATION AT THE NANOSCALE

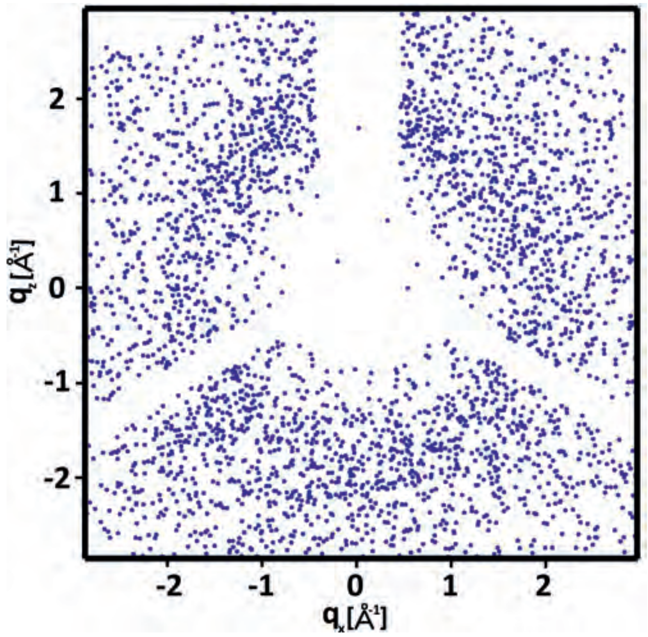
HOW DO PARTICLES JOIN TO FORM STRUCTURES?

For decades, scientists have been trying to understand the structure of nanoscopic systems; nevertheless, there is still a very limited knowledge about these systems. Unlike crystalline solids, disordered materials as liquids or glasses lack translational order, i.e. there is no long-range periodic structure. However, they can form different local structures. Computer simulations, for example, suggest a pentamerous, icosahedral local order for many liquids. Such symmetries possibly exist only for a short time, but they may be responsible for the characteristics of supercooled liquids and the existence of the glassy state.

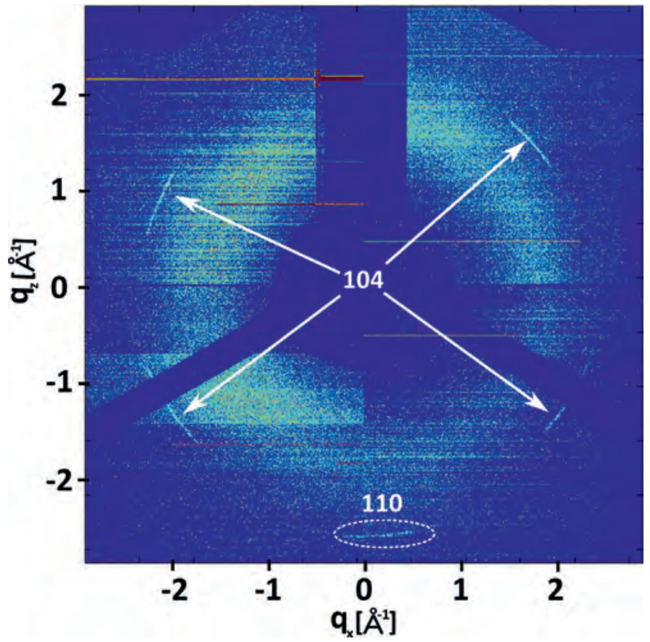
Several user facilities are available to study such systems: the extremely brilliant X-ray sources found at DESY’s PETRA III, ultrashort and coherent X-ray pulses of free-electron lasers as provided by the LCLS at the US accelerator center SLAC or, and before long, the European XFEL in Hamburg. By using these facilities, the knowledge-gaps can nowadays gradually be closed. They are part of the CUI research area C, “Dynamics of Order Formation on the Nanoscale.” Altogether, the research teams in this research area are focused on three main areas.

Within research focus C.1, scientists investigate colloidal and molecular liquids. They place a special emphasis on the question of whether orientational order may be (co-)responsible for the glass transition and to what extent transient local structures can explain the peculiar behaviour of complex liquids such as water. To reveal such local structures, the research teams developed new analysis methods for both issues, such as X-ray cross correlation analysis (XCCA) and novel sample environments, such as liquid micro jets which make the smallest sample volumes accessible.

With the ultrashort LCLS X-ray pulses, it is possible to take single 100 femtosecond (fs) snapshots of water (see image, above left). The weak scattering ring at 2 $Å^{-1}$ defines the structure factor of water, and each dot reveals the location of a scattered photon in the detector. More than one million of these single images must be analyzed to obtain information on the local structures in water.



Single scattering image of a water droplet irradiated with a 100-fs-long LCLS X-ray pulse



Sum of 2000 scattering images of a hematite/water sample with(104)/(110) scattering reflections generated by aligned hematite particles

To visualize the shear force in the liquid jet, small colloidal hematite particles were added to the water sample and 2000 single snapshots were summed up (see image, above right). The circular-segment-shaped scattering signals show that the spindle-shaped hematite particles are not aligned at random but mostly align close to the nozzle parallel to the water jet.

Liquid jet systems also allow the study of the nucleation and growth of nanoparticles: Very small nanocrystals reveal atomically defined structures with molecular orbitals governing the electronic and optical properties. With larger nanomaterials, a transition takes place to macroscopic bulk properties and to a continuous electronic band structure.

Within research focus C.2, scientists study the structural formation and growth of nanomaterials and its transformations triggered from outside (see p. 4-5). X-ray scattering and spectroscopic methods are used to investigate the corresponding dynamics and kinetics on the atomic level. These methods allow monitoring of the ongoing processes on the relevant time and length scales. Further interesting questions are centered on how surface modifications with ligands influence the properties of nanoclusters and how nucleation and growth appear in confined geometries, such as porous matrices.

Research focus C.3 concentrates on dynamics of ferromagnetic nanostructures. Ultrafast spin manipulation opens up an enormous potential for applications in information storage, processing and access. This stimulates a growing interest in the excited states and non-equilibrium properties of magnetic nanostructures. Important questions are how quickly is it possible to switch the magnetisation of ferro- and superparamagnetic nanostructures? and how are the ground and excited states influenced in interacting nanostructures? By using resonant magnetic X-ray scattering and through magnetic transport measurements, CUI scientists hope to find answers to these questions. Additional investigations use ferromagnetic resonance spectroscopy. By means of nuclear resonance scattering, spin waves are examined in lateral ferromagnetic nanostructures, for example spin ice. ■

Within research area C, scientists of DESY, Universität Hamburg and the Max Planck Society work on time resolved studies of ordering phenomena at the nanoscale level, with three main research focuses: Research focus C.1 addresses the role of transient structures in molecular liquids such as water, and the role of structural correlations for the glass transition. Scientists of research focus C.2 investigate nucleation and growth processes of nanoparticles and correlate their shape and phase transformations with external triggers. Research focus C.3 analyzes ultrafast spin ordering processes in nanostructured systems.

Fluorescent light changes depending on the size of CdSe-based quantum dots

NANOPARTICLES OPTIMIZE IMAGING IN MEDICINE AND TECHNOLOGY

TRIUMPH OF QUANTUM DOTS

For 30 years, research teams all over the world have focused their attention on semiconductor nanocrystals. In the laboratories of the CUI research groups headed by Professor Horst Weller and Professor Alf Mews, scientists are also concerned with these special crystals. In these crystals, a gradual transition takes place from molecular structures to bulk solid states. This is manifested in the fact that the energy difference between ground and excited states becomes a function of size. As a result of the so-called quantum size effect, the color of the fluorescent light changes according to the particles' size. Small CdSe particles, for example, with a particle diameter of about 2 nm emit blue light while those of about 5 nm emit red light (see Fig. 1). By virtue of these special properties, these particles, named quantum dots, have nowadays found their way into important fields of application.

An interesting field is the visualization of biological processes. In this area, quantum dots are used as biomarkers coupled to antibodies, which in turn initiate a specific adherence to and absorption into body cells. From this process, scientists are trying to develop specific tumour markers for early diagnosis and agent delivery systems which supply medication only to diseased cells, among other things.

As biomarkers, nanoparticles offer considerable advantages over conventional molecular compounds. Quantum dots practically do not bleach out under illumination; all of them can be excited by only one single laser, and their fluorescence bands have a very narrow spectrum. Moreover, they catch the incident light with extreme efficiency which makes the luminous power of single particles high enough so that they are easily detectable under the microscope.

The so-called superparamagnetic nanoparticles based on iron oxide are already used today in medical imaging. By adjusting the particles' size and shape, it is possible to determine their magnetic properties, thus optimizing them for contrast generation in magnetic resonance imaging scanners.

Parallel to the biomedical advances, a major application area opened up in the field of lighting and display technologies in recent years. LEDs are increasingly replacing conventional light bulbs and fluorescent tubes, and they are unrivalled as backlighting for television, cell phones, and computer displays.

The actual LED radiates blue light for these applications, and with a coating of a phosphorescent material emitting yellow light, it produces the combination color white. This luminescent material has a wide emission spectrum, although it produces a very small amount of green and red light. Even though we see white light with the LEDs, we do not perceive it as daylight. Thus when used for lighting purposes, we miss the feeling of "well-being", and in the display field, shades of red and green are not presented realistically. Curiously enough, today's well-established LED television sets have a considerably inferior color rendering compared to the old and bulky tube TV sets. However in 2013, Sony brought to the market the first television set with color-fidelity LED backlighting. This was possible as quantum dots emitting red and green light replace the yellow luminescent material. This kind of extremely brilliant color reproduction meets the highest standards. Similar concepts are planned in the field of lighting technology in order to obtain a more pleasant color perception.

Crucially important for all of these applications is a precise control of the nanoparticles' size, shape and composition, and a precise reproducibility in large-scale production. The synthesis of nanoparticles is subdivided into two phases: a very fast nucleation phase followed by a substantially slower process of growth. Both are influenced by the choice of chemical precursors, complex ligands, added surface-active molecules, solvents, temperature, and even the mixing conditions of the components. This is why synthesis concepts developed today are based almost exclusively on empiricism and usually only work when preparing small amounts of material. The understanding of the processes taking place and models describing the theory, as it is known in molecular synthesis chemistry, are only available as rudimentary approaches. Thus, the ambitious goal of our research activities is to shed light upon these processes. ■

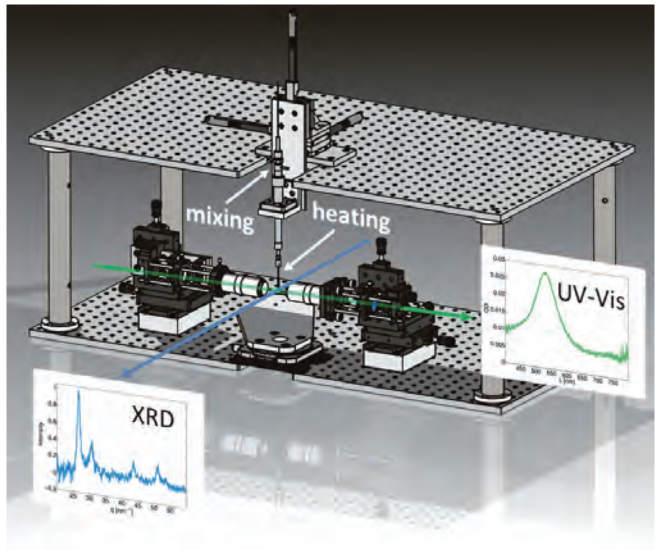
Hope for a scientific breakthrough

The Holy Grail of nanotechnology: How are nanocrystals created and grown?

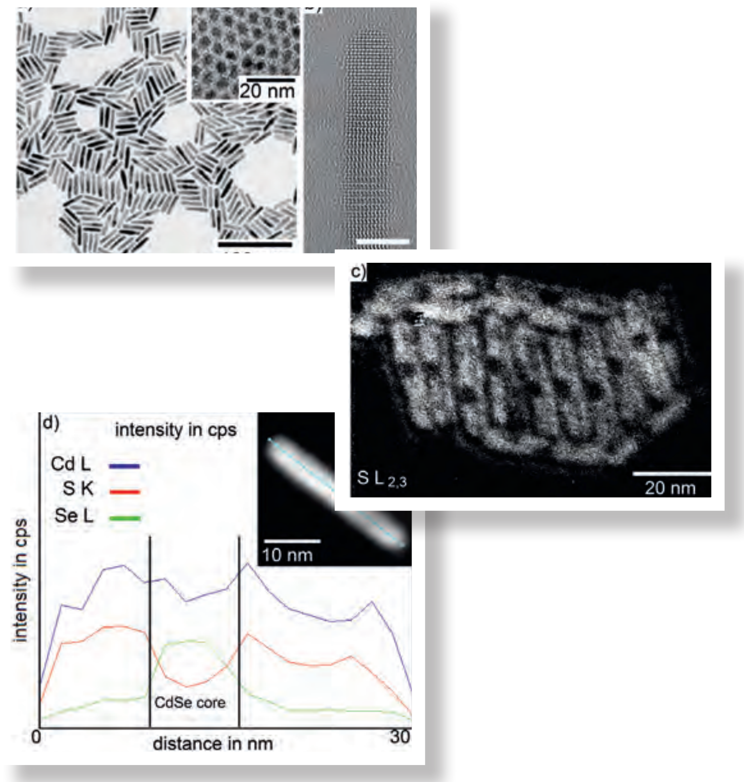
Modern electron microscopy methods investigating grown particles have been continually evolving (right); however, these methods are only of very limited help to explore how particles are formed. With new light sources, the research teams now hope for a decisive breakthrough: their investigation will not only include the structure of small nucleation seeds but also the alteration of their shape, crystalline structure, and ion exchange processes during growth by the use of time-resolved X-ray diffraction and optical spectroscopy.

The first two years of the CUI project were marked by the implementation of appropriate instrumental setups which allowed the groups to carry out reactions within the right time window and to observe processes in situ. There are two concepts: The group headed by Professor Horst Weller (University of Hamburg) built a fluidic system based on microfluidic components with thermal and sample loops; the group headed by Professor Alf Mews (University of Hamburg) installed a free-standing jet system (top). 3). Both systems provide complementary results. The fluidic system covers a large parameter space regarding different reaction conditions, e.g. temperature, mixing and growth periods, and material compositions, whereas the free-standing jet system allows a nearly background-free investigation of optical and structural properties. Thus starting compounds can be brought to reaction immediately before the nozzle by increasing the temperature and subsequently be investigated in the free liquid jet simultaneously with X-rays and optical microscopy.

After the first successful test measurements at X-ray sources, the range of possible particle syntheses will now be extended in order to continue measurements at DESY's X-ray source PETRA III. The research groups also want to initiate the dynamics of particle formation and transformation in pulsed laser experiments and carry out time-resolved tracking. Moreover, experiments are planned at free-electron laser sources to directly observe the time sequence of structural changes with pulsed X-ray radiation.



Free-standing jet system to simultaneously investigate nucleation processes with X-ray diffraction and absorption spectroscopy



Electron-microscopic photographs of CdSe-CdS nanocrystals, where rod-shaped CdS was grown on the surface of quasi-spherical CdSe particles.

Above: Overview photo and CdSe cores, and a high-resolution picture showing the crystal lattice planes.

Center: Energy-filtered photograph. The areas containing sulphur appear bright, the cores containing Se are dark.

Below: The elemental composition was determined with virtually atomic resolution along the turquoise-coloured line by using X-ray fluorescence analysis. Here, you also see that CdSe only appears in the centre whereas the CdS part grew rod-shaped along the crystal axis

Enriching the culture on campus

INTERNATIONAL STUDENTS APPRECIATE THE GOOD WORKING ATMOSPHERE

Pankaj Kumar Mishra (left) sees his future in the academic field. Mona Rafipoor has not yet decided – but she would like to live half of the time in Germany and half of the time in Iran.

Salah Awel would like to become a professor in Africa

Internationalization – that means not only co-operations in research across boundaries, but also competing for the best brains, the best research, and the best reputation. It enriches the culture at universities and increases the potential for creativity and innovation. This is evident in cutting-edge research in natural sciences and is reflected in the Graduate School of the CUI. Three students from India, Ethiopia and Iran tell us about themselves:

Pankaj Kumar Mishra came from India in March 2012, after having finished his B.Sc. at the University of Allahabad, U.P. – which was known as the "Oxford of the East" in the past - and his Master of Science in Physics at the India Institute of Technology (IIT) Guwahati, Assam. IITs in India are similar to German TUs and are famous for their technical education. Mishra worked a year and a half as a research assistant at IIT Kanpur and then started looking for a PhD position. His cousin in Kiel drew his attention to the good opportunities in Germany – a chance which the Indian was glad to take: "I'm extremely happy about the research and working environment here. I am also very happy about the city and so far I have never felt unsafe." He appreciates the city's internationality and is nicely networked in the Indian community. Mishra: "There is a close connection between India and DESY. India has contributed to the construction of the PETRA III extension at DESY. One of the beamlines (P22- X-ray Nano-Spectroscopy) is even called the Indian/German Beamline." The theorist from Prof. Santra's group sees his future in the academic field – preferably as a professor in a good institute or university.

All three of the CUI members agree that it is decidedly difficult to find an apartment in Hamburg. Mishra: "In the beginning, I was living in a house with some restriction. After 10 pm, I wasn't allowed to do anything. Now I am living in the small house of a lawyer with a nice flatmate originally from Hamburg with whom I sometimes cook together with." Luckily, there are good Indian restaurants and many Indian shops in Hamburg.

Good food – Iranian food, to be precise - is also very important for Mona Rafipoor. The young scientist's family from Teheran has close connections to Germany: Her father worked as professor of Sociology in Tübingen and Hohenheim, one of her three brothers is a PhD student in Tübingen, and the other one is doing his PhD with the European XFEL in Hamburg. Rafipoor finished her Bachelor in physics in Teheran – where more of her colleagues were women. "This is something usual in Iran," Rafipoor says. She then came for her Master study to Hamburg and did her thesis in the group of Prof. Klaus Sengstock. When she was looking for a postgraduate position she found it again in Hamburg as an experimental researcher in the group of Prof. Holger Lange.

"I'm very content, but Hamburg is not my home – home is something different to me. Everything in Hamburg can be planned, everything functions. But Iran is more lively. In the beginning, it was not so easy for me in Germany like it is now," Rafipoor says. She has not yet decided about her future plans. Preferably she'd like to live half of the time in Germany and half of the time in Iran.

Salah Awel has Africa in his mind for his future plans because he would one day like to help his country: The Ethiopian is first planning to finish his PhD, then to do his postdoctoral studies in maybe another country and finally – this is the dream – he'd like to become a professor of physics at a university in Africa. The PhD candidate from Addis Ababa finished his BS in electrical engineering at the University of Bahir Dar, the third biggest city of Ethiopia on the shore of Lake Tanar, the source of the Blue Nile. Many friends went to the USA after their Bachelor, while Awel was granted a scholarship from the Universität Erlangen and decided for Germany. Awel: "It was very pleasant in Erlangen. Here it is more difficult to make friends." When looking for a postgraduate position he first came across DESY, then Universität Hamburg and finally applied directly to Prof. Henry Chapman. He likes the working atmosphere, but he also appreciates the opportunities which a city like Hamburg offers.

Graduate Days: In the special colloquium "A Hitchhiker's Guide to Atom Gazing" Prof. R. J. Dwayne Miller prepared his audience for a science slam

Prof. Ralf Röhlsberger's team used the whole body to demonstrate how spin waves work

Training Program tailored for CUI

FRESH RESEARCH PERSPECTIVES IN AN INTERDISCIPLINARY TEAM

Enthusiasm, impartiality and fresh perspectives are the hallmarks of many junior scientists. This is why postdocs and PhDs are one of the driving forces in outstanding research projects. They work in laboratories where they perform measurements, set up samples, or develop theoretical concepts which lead to a specific expertise in highly demanding, but usually well-defined research fields. These clear segregations disappear successively at CUI as the research areas touch topics of physics, chemistry, biology, and medicine – and as the groups are multiply cross-linked. "Those who work at these interfaces not only have to know different scientific concepts but also must be able to interrelate them in a sensible way," Prof. Peter Schmelcher says. Based on this, the head of the graduate school designed a training program especially for CUI.

Schmelcher: "The young scientists, who want to be successful in their research at CUI, need a strong interdisciplinary training that takes account of the specific aspects of each research area and merges these." Therefore all PhD students are automatically graduate school members. Once a year the Graduate Days of CUI offer a broad program of scientific and soft skills courses.

The training program is made of several packages including interdisciplinary modules. The students arrange their personal curriculum in the field of Ultrafast Imaging:

- Single modules that explicitly refer to only one research area
- Joint modules of different research areas, the knowhow of which can be applied to at least two modules
- Global modules that impart techniques, experimental methods and theoretical knowledge that are needed in all three research areas

The modules include introduction courses, lectures, seminars, journal clubs, tutorials, colloquia and workshops. Since the heads of the research groups are responsible for the training program, the PhD students and postdocs participate in all areas of the cluster in research projects at the highest level.

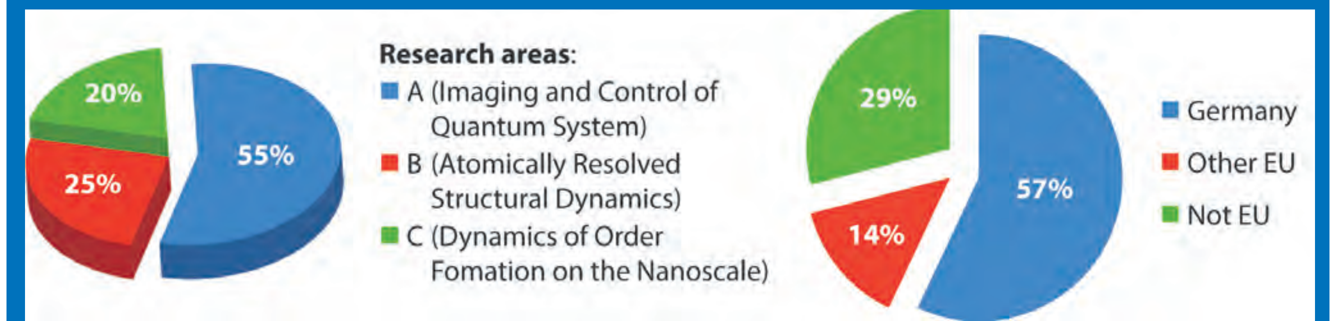
The head of the graduate school considers professional mentoring with career planning and further development of social skills as very important. Thus PhD students organize their own winter schools; the graduate school supports guest programs, colloquia and participation in international workshops. Once a year the Graduate Days of CUI offer a broad program of scientific and soft skill courses

Regular feedback is of particular importance for the project's success and the personal development of the young scientists. In addition to the doctoral thesis supervision, every PhD student has a co-advisor at his or her side. The young scientists meet their personal advisory team twice a year in order to discuss their level of training, their research results and future trainings, and to plan their further career. Schmelcher: "Excellent opportunities are offered here to reach completely new horizons together with experienced scientists in an interdisciplinary team." ■

CUI Graduate School

At present the CUI Graduate School has 99 members, 41 postdocs (ten women), and 58 PhD students (13 women).

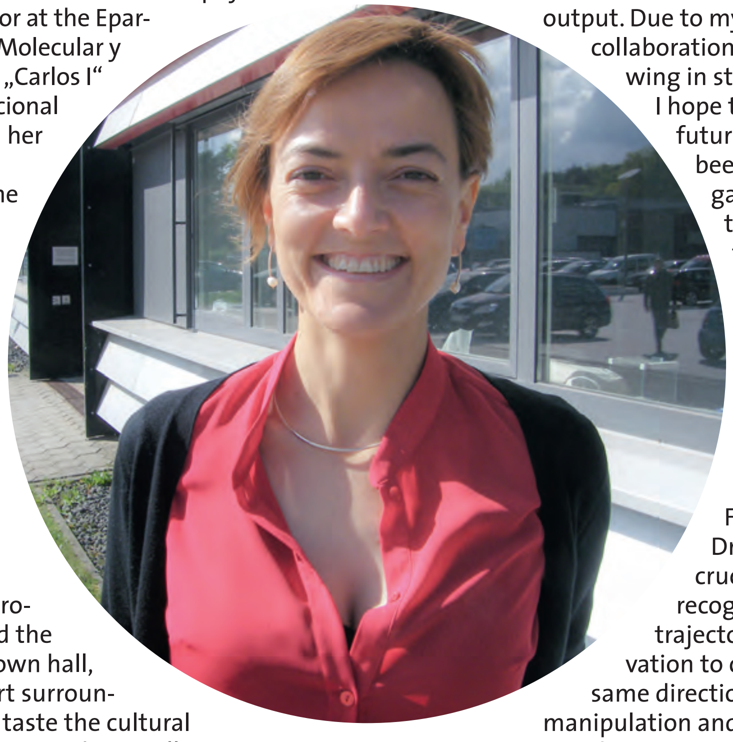
Distribution according to research areas and origin:



MILDRED DRESSELHAUS AWARD HAS LONG LASTING EFFECTS

PERMANENT INFLUENCE ON RESEARCH AND CAREER

In the year 2013 the Spanish professor Dr. Rosario González-Férez joined the CUI as the first Mildred Dresselhaus guest professor: each year the CUI offers two outstanding female scientists a research stay in Hamburg. The idea is to build up novel possibilities of collaborations, to intensify existing contacts, and to establish role models for young women in physics. Since her guest professorship, Dr. Rosario González-Férez has returned to Hamburg regularly – depending on her teaching schedule. The theoretical physicist is an associate professor at the Epartamento de Fisica Atómica, Molecular y Nuclear and at the Instituto „Carlos I“ de Física Teórica y Computacional in Granada. CUI News asked her about her experiences as a guest professor and what the award means for her career.



Dr. González-Férez how did you experience Hamburg?
Rosario González-Férez: Apart from the science, it was a great experience to live in Hamburg. During my visits, I enjoyed the atmosphere of the city in all seasons of the year. Needless to say, I prefer the summer and spring. I even managed to be a „local cicerone“ for some friends around the Alster, the city center, the town hall, the river, the impressive port surroundings,.... I have also tried to taste the cultural flavor. I was fascinated by the Hamburg Ballet, something we don't have in Granada. I go back home, knowing that I have many friends in Hamburg.

What was your main research focus?
Rosario González-Férez: My research at the CUI has been devoted to exploring the dynamics and structure of different molecular systems. In collaboration with Prof. Peter Schmelcher, I have investigated ultralong-range triatomic Rydberg molecules which are formed by a Rydberg atom and a ground state polar diatomic molecule. The features of these exotic molecular species open unprecedented opportunities for their control by means of weak electric fields. Motivated by the experimental results from the group of Prof. Jochen Küpper, I have investigated the non-adiabatic dynamics of linear molecules in combined electric and laser fields. These theoretical studies allowed us to understand and interpret the experimental observations of non-adiabatic alignment and field-free orientation of linear molecules. We still have some open problems in this project.

Have your expectations been fulfilled?
Rosario González-Férez: I am very happy about the output. Due to my CUI stays, my scientific collaborations have been gradually growing in strength and diversity, and I hope they will continue in the future. In addition, there have been excellent results, which gave rise to several publications in prestigious scientific journals. Moreover, we are presently preparing other manuscripts with our latest achievements.

Has the award changed your self-conception as a scientist?
Rosario González-Férez: For me, the Mildred Dresselhaus prize has been crucially important. It means recognition for my scientific trajectory, being a strong motivation to continue working in the same direction; namely, the structure, manipulation and control of molecular systems under external fields. The prize has also allowed me to carry on research under the excellent scientific conditions that the CUI provides.

What are your future plans?
Rosario González-Férez: Scientifically, I plan to continue my work on the impact of electromagnetic fields on complex molecules at the University of Granada. Some of these projects are long term, and they will keep me busy for some time. Except for short scientific visits or conferences, I will stay in Granada. It would be a great pleasure to go back to Hamburg and CUI again in the near future.

Thank you very much for this interview. ■

Mildred Dresselhaus Guest Professors:

- Prof. Elspeth Garman, University of Oxford, United Kingdom (2015)
- Dr. Liesbeth Janssen, Columbia University, New York, USA (2015)
- Prof. Roseanne Sension, University of Michigan, Ann Arbor, USA (2014)
- Dr. Anouk Rijs, Radboud Universiteit, Nijmegen, The Netherlands (2014)
- Prof. Tamar Seideman, Northwestern University, Chicago, USA (2013)
- Dr. Rosario González-Férez, Universidad de Granada, Spain (2013)

MENTORING PROGRAM FOR WOMEN IN NATURAL SCIENCES

In order to facilitate the conditions for both men and women, CUI has set up an ambitious action plan which aims at improving the reconciliation of work and family life plus at increasing the number of female scientists on all levels of a career. In addition to a variety of flexible measures, the integral parts of the plan are the new program "Mentoring for women in Natural Sciences", the Mildred Dresselhaus guest professorship program, and the Louise Johnson Fellowship which are all addressed to female scientists.

„Mentoring for Women in Natural Sciences" is a joint program of CUI, DESY, the collaborative research centers SFB 676 and 925 as well as the PIER Helmholtz graduate school. It addresses female PhD students and Postdocs, giving them the chance to take part in intensive talks with an expert female mentor and to listen to their personal experiences, to discuss professional challenges or to plan the career steps. In addition, it offers networking-events and workshops over a period of twelve months. "We are very happy to be able to offer a mentoring program to female scientists in cutting-edge research that supports the participants in an optimal way on their individual career paths," says Marie Lutz, equal opportunity officer at the CUI, who is leading the project together with Sylvie Faverot-Spengler, equal opportunity commissioner at DESY. To guarantee the most suitable mentor for the mentee, the project leaders are supported by the Expertinnen-Beratungsnetz/Mentoring of Universität Hamburg. Furthermore, the project is supported by the MIN faculty of Universität Hamburg. "What is exceptional about the mentoring program is the cooperation between the partners that are located on Campus Bahrenfeld. We pool our competences in "womanpower" thus enabling an equal opportunity measure across institutions addressing and connecting women from different research institutions," stresses Faverot-Spengler.

The "Mildred Dresselhaus Award" has been established to promote outstanding female scientists. It is given to a successful senior scientist and to a younger scientist with high potential, who are then invited to perform research at the CUI for a period of up to six months. Thus the CUI wants to attract world leading researchers to Hamburg, to start new and to intensify existing collaborations – and in doing so to establish role models for young women in the physical sciences. The program was named after Mildred Dresselhaus, Professor of Physics and Engineering at the Massachusetts Institute of Technology (MIT), who is a clear role model and leader in promoting opportunities for women in science and engineering.

The Louise Johnson Fellowship allows female postdoctoral research associates to perform research at the CUI for a period of two years. The late Dame Louise Johnson (University of Oxford) was a renowned professor of Molecular Biophysics and pioneer of protein crystallography. She had an international role in advising on the exploitation of synchrotron radiation for biological research and was fascinated by the CUI's interdisciplinary research program. ■

This fellowship is an achievement for me

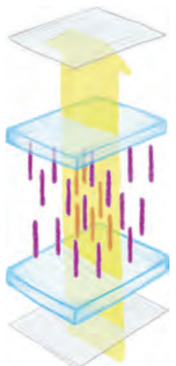
Chemist Dr. Amanda Steber, CUI's first Louise Johnson Fellow, says: "The facilities at CUI and in Hamburg lend themselves to the work that I would like to accomplish. Not only do they possess the instrumentation, such as in the lab of Dr. Melanie Schnell, but they also have a large scientific community that I can take advantage of."

"This fellowship is an achievement for me. I have always had some doubt about my place in the scientific community, but when I read about this fellowship and the woman behind it, it felt like the right path. I am very interested in melding my work in spectroscopy with a cause for the greater good, and I think this fellowship is that chance."

KEEN ON PHYSICS

How can you attract young people to the natural sciences? Dortje Schirok has been thinking about this question for several years already. Together with Dr. Thomas Garl, she coordinates the school lab "Light & Schools" and has developed a broad program with many topics for schoolchildren from grades 5 to 13. They get the chance to experience science directly on Campus Bahrenfeld surrounded by high end research institutions but in projects exactly tailored to their needs and interests.

"We have to show the kids topics from everyday life and try to inspire them," Schirok says. Mobiles seem to be ideal objects to reach this aim. "Everybody has one and it is very important for young people," the physicist explains. Because of this, she developed a project about Liquid Crystal Displays which are being used in a wide range of technical devices: in flat screens, telephone systems, calculators, and mobiles. This project allows students to create their own display, for example using a pixel in the form of a smiley. In addition, Schirok developed a manual without technical presentations: "In using hand drawings, we try to appeal to aesthetic feelings, so that we can also reach students who do not find easy access to technical topics." In this way Schirok hopes to show that also high technology is understandable.

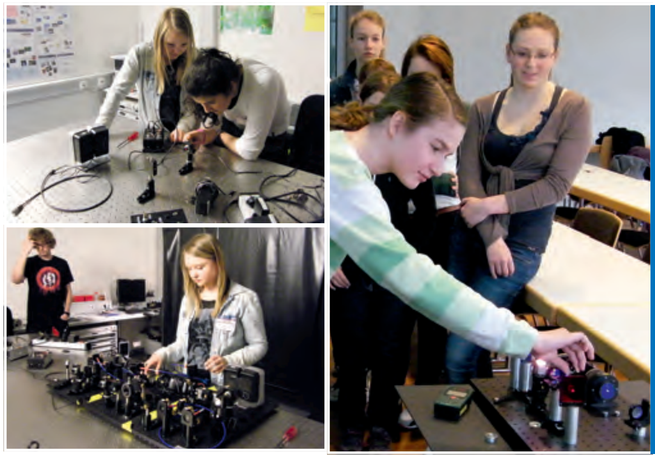


The project addresses students from grades 7 to 10 and ties in with the projects for grades 11 to 13 which Dr. Thomas Garl has developed since the starting of the school lab in 2009. "Light & Schools" was originally developed within the excellence initiative of the state government and has been generously supported by the Joachim Herz Stiftung. Dortje Schirok joined in with the beginning of the CUI in 2012 and since then many ideas have been implemented.

Today "Light & Schools" cooperates successfully with numerous schools in Hamburg. The aim is to build up long lasting co-operations and offer courses for all phases of school, so that the students get the chance to visit a couple of times. "The ideal concept is that visiting us becomes a fixed part of physics classes, so that the teachers can really prepare and follow up on what is happening here," Schirok says. During the experiments, the teachers are asked to spend their time somewhere else on campus, so that the students can enjoy their time without thinking of being assessed. Additional projects explain the functioning of lasers and GPS systems, or they let students develop their own app.

How do GPS systems work? The school lab always combines theory with experiments

Besides attracting young people in general to the natural sciences, "Light & Schools" puts special emphasis on addressing girls. Each year in spring a group of girls gets the chance to visit "Light & Schools" and participate in the Girls' Day. Moreover, the school lab participates in mint:pink, a program initiated by the Initiative Naturwissenschaft & Technik NAT gGmbH, where girls from diverse schools get to know about research institutions, companies and universities. "We were very excited about this program and immediately decided to participate," Schirok says. The CUI coordinators tailored the project "pink is not a color" exactly to this program; however, the questions about light and color turned out to be so interesting for the girls, that the project has become a fixed component of the "Light & Schools" curriculum. ■



Girls' Day: Life as a researcher

"It's not true that physics is for men only," Prof. Klaus Sengstock, CUI speaker and director of the Institute of Laser Physics, said, when greeting a group of girls who used the chance of the Girls' Day to get insight into research.

Proving his words, Dr. Thomas Garl asked four female junior scientists to talk about their life as researchers. Thanks to this type of personal approach, it is often easier for the girls to find access to physics. After theoretical input, "Light & Schools" always offers the chance to actively create.

HAMBURG PRIZE FOR THEORETICAL PHYSICS:

PRESTIGIOUS AWARD HONORS OUTSTANDING SCIENTISTS

Each year CUI and the Joachim Herz Stiftung jointly award the "Hamburg Prize for Theoretical Physics". The prestigious prize honors outstanding contributions of a highly accomplished international researcher in the field of photon science, especially quantum optics, laser physics, ultrafast physics, and X-ray physics. "The prize strengthens Hamburg as an international research center and especially promotes the interdisciplinary exchange with young scientists", says Petra Herz, Chairwoman of the Executive Board of the Joachim Herz Stiftung. The award comprises a certificate and personal prize money of 40,000 Euro. Moreover, it is connected with a research and teaching stay at the CUI.

In 2013, the "Hamburg Prize for Theoretical Physics", was given to **Prof. Dr. Chris H. Greene,** Distinguished Professor of Physics at Purdue University, West Lafayette, USA. Chris Greene's work provides an understanding of Rydberg molecules and eventually led to their experimental discovery. Although they are large as viruses, these molecules are made up of only two atoms. They are rather unstable but can be manipulated very easily. Research teams all over the world try to generate and manipulate such molecules in order to study the change of chemical and physical properties of the original matter. Put in simple words: Water could theoretically exist not only in its 'normal' form as a liquid or as ice. In the special binding form of Rydberg molecules ice would be extremely airy and gigantic – a conventional scoop of ice-cream could be as large as a football stadium.

As early as the year 2000 Chris Greene had already developed the theory of an unusual binding mechanism in ultracold quantum gases of high density and predicted the existence of such Rydberg molecules. Guided by his calculations, a group of experimental physicists in Stuttgart synthesized two rubidium atoms into such a gigantic molecule for the first time in 2008. The research on this new class of molecules enables completely new insights into the dynamics of atomic bonds in chemical compounds.

In 2014, the "Hamburg Prize for Theoretical Physics" was given to **Prof. Dr. Antoine Georges,** Professor at Collège de France, École Polytechnique, and University of Geneva. Prof. Georges' work in the field of theoretical solid state physics has opened the understanding of how the properties of materials, such as metallic or insulating oxides, are influenced by their structure and by the interactions between electrons at the atomic scale. Since a solid consists of roughly 10^{23} particles/cm^3 – a figure with 23 zeros - it is necessary to find a description which simplifies the interplay of electrons but at the same time captures the properties of a certain material as realistically as possible. This situation can be compared to a Mexican wave: to understand why the wave proceeds through a stadium and when it subsides, one has to observe how the fans react to external conditions like the overall atmosphere, the ongoing football match, and the behavior of the other supporters. The wave emerges as a result of the interplay of the football fans, a "correlated" behavior.

Petra Herz, Chairwoman of the Executive Board of the Joachim Herz Stiftung (center) and Hamburg's former second mayor Dr. Dorothee Stapelfeldt (until April 2015) congratulate Prof. Dr. Antoine Georges on the prestigious award

Antoine Georges' models lead to a description of properties of materials with strongly correlated electrons. In addition, his research provides important insight into the interface of theoretical solid state physics and materials science: new materials with correlated electrons, for instance, could be used in sensors, switches or other novel electronic devices.

The "Hamburg Prize for Theoretical Physics" was originally established in 2010 by the state cluster of excellence "Frontiers in Quantum Photon Science" at Universität Hamburg. The previous awardees are Prof. Maciej Lewenstein (2010), Prof. Peter Zoller (2011), and Prof. Shaul Mukamel (2012). From the beginning the prize was supported by the Joachim Herz Stiftung, and from 2013 on the foundation has continued its engagement together with CUI. The 2015 award will be presented during CUI's international scientific symposium in November. ■

PORTRAYING NEW CUI PROFESSORS

What drives scientists, what motivates them, which career path do they follow? During the last 2.5 years, CUI has attracted six new professors to do research at the interface of physics and chemistry.

Prof. Ulrike Frühling started her professorship as a young mother

ULRIKE FRÜHLING ENJOYS GAINING KNOWLEDGE

Prof. Ulrike Frühling likes to compare her research with a general cultural interest: "Just like many people feel the need to go to the theater, others have the need to understand nature." The economic benefits would often only be revealed many years later. A good example is quantum mechanics: "I think that people in those days just thought it would be fun to understand the concepts. Nobody could have known that this would lead to a personal computer."

For almost two years now, the physicist has been doing fundamental research at CUI. Her work focuses on single molecules in the gas-phase. Frühling and her working group observe the processes in these isolated molecules, and specifically analyze how fast the chemical processes run. In order to do so, they use ultrashort flashes operating at different wavelengths ranging from near X-rays to intensive far-infrared radiation (THz). These experiments help to follow up ultrafast dynamic experiments in the range of pico- and femtoseconds. Prof. Frühling: "We test the models that are calculated by theorists and return our results to theoretical physics." On the long run, such research results could be useful in chemistry, but the junior professor considers first of all the gain of knowledge most worthwhile.

Gaining knowledge has always been her driving force – at school, during her studies of physics in Freiburg and Melbourne and while working on her doctoral thesis at FLASH. After her postdoc, the birth of her daughter in year 2012 brought a very new facet into the scientist's life. After a short period of parental leave she started to work with reduced working time, lasting four months into the beginning of her junior professorship: "That was quite bizarre. The administration of the MIN-faculty did not know at first how to manage a professor in parental leave. Evidently this hadn't happened very often in natural sciences." Today Ulrike Frühling has two children. ■

Prof. Holger Lange experienced absolute freedom of research in New York

HOLGER LANGE COMBINES PHYSICS AND CHEMISTRY

One needs to represent something" – Prof. Holger Lange internalized this tenet. During the recent years the physicist got to know a wide array of topics and situations: new and perfectly equipped laboratories in Karlsruhe, the focus onto a rather technical topic at The Max Born Institute for Nonlinear and Short Pulse Spectroscopy, Berlin, policy on higher education in Berlin and the absolute freedom of research at the Columbia University in the city of New York. Lange: "They work totally differently in the USA. Research is financed completely via external funds and is very up to date since new topics are picked up quickly, and many people can immediately be committed to new projects."

At CUI the junior professor now focusses on time-resolved spectroscopy of nanostructures. The emphasis is on questions such as: what happens when small structures are brought together, which interactions do occur and what do they depend on? Lange: "This means that in my research group we will do a lot of method development and at the same time work with very interesting materials."

As a PhD student in Karlsruhe Lange did not necessarily aim at a scientific career. But he was already fascinated by scientific questions – for example, if zinc oxide nano-rods could work as nano-lasers. Lange: "It is hugely motivating to ask questions which others are also interested in, and to develop different approaches step by step and to then find the right answer."

Since Lange had in the past worked on several projects together with Prof. Horst Weller and Prof. Alf Mews, he decided to apply to CUI. "Hamburg has been a good decision also privately." Though the city is smaller than Berlin and New York, it is still large enough to offer interesting cultural activities. In solidarity with his wife, a doctor, Lange gets up particularly early in the morning and uses that time for jogging. ■

GABRIEL BESTER: SCIENTIFIC FREEDOM RATES HIGH

Prof. Gabriel Bester: "CUI fits perfectly."

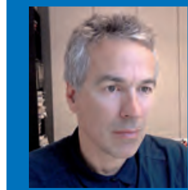
When Prof. Gabriel Bester talks about his research of the optical characteristics of semiconductors, one gets the impression of listening to a real Southern German. Indeed as the son of a French mother and a German father, he grew up in Geneva – neutral territory, as his parents used to say. As a native French speaker he obtained his high school diploma in Montpellier. Searching for his German roots Bester went to Stuttgart to study physics and wrote his dissertation in 2001 at the Max-Planck-Institut für Metallforschung. "I am still using the theoretical methods that I learned there", the CUI professor says. Eventually he pursued his scientific career in the USA with Prof. Alex Zunger, a pioneer and frequently decorated researcher in the field of electronic structure calculation.

Bester and his wife spent six years in the USA: "Boulder is a vivid students' city, and we felt quite at home there. Both of our daughters were born there, but one day we were wondering if we preferred living in the USA or in Europe as a family." They decided for Stuttgart again, because at the Max Planck Institute a position in a junior group of solid state research offered access to mainframes and was very well equipped. Bester: "This was perfect. In the USA I would have been bound to specific projects financed from third-party funds, in Stuttgart I simply had more freedom that I needed for my methodological development." Scientific freedom rates high for Bester – he considers this as very motivating in combination with young people who are enthusiastic about their work.

For a further six years he performed research together with his group on semiconductor-nanostructures and developed his calculation method, based on the density functional theory, to the point that it can be used in many different ways today. "It is a very accurate method and the work is practically finished. Now I'd like to use it for describing time resolved phenomena and CUI is perfect for this", Bester says. The aim of his working group is to work out concepts and to implement them in computer programs in order to understand and to predict fundamental characteristics of matter with nanoscopic length scales.

Bester: "By spending our leisure time climbing and skiing, we unfortunately are tied to the mountains. But scientifically Hamburg has been a clear decision." The big advantage is, so he says, that exactly the relevant groups work at CUI that are located somewhere between physics and chemistry – just like himself. ■

Honors and Awards I.



Prof. Andreas Hemmerich (Universität Hamburg) has been selected as Outstanding Referee by the American Physical Society (2013).

The Optical Society of America has awarded the Charles Hard Townes Award 2013 to **Günter Huber** (Universität Hamburg) for his outstanding contributions to quantum electronics and laser physics (2013).

The European Research Council supports the research project "Frontiers in Attosecond X-ray Science: Imaging and Spectroscopy" (AXSIS) of **Prof. Franz Kärtner** (Universität Hamburg, DESY, left), **Prof. Henry Chapman** (Universität Hamburg, DESY, right), Dr. Ralph Aßmann (DESY), and Prof. Petra Fromme (Arizona State University) with a Synergy Grant of € 14 million (2013).

Prof. Jochen Küpper (Universität Hamburg, DESY) has received an ERC Consolidator Grant of approx. € 2 million for his project „Controlling the Motion of Complex Molecules and Particles" (2013).

Prof. Henning Moritz (Universität Hamburg) has been granted an ERC Starting Grant of € 1.2 million for his research on small quantum systems (2013).

Dr. Xiaojun Wu (DESY) has received a research stipend for postdocs from the Alexander von Humboldt-Stiftung (2014

Prof. Peter Schmelcher (Universität Hamburg) has been announced as Outstanding Referee by the American Physical Society (APS); in addition he has been appointed to the Commission on International Freedom of Scientists (CIFS) (2013).

Dr. Melanie Schnell (Max Planck Institute for the Structure and Dynamics of Matter) has received the Helene-Lange-Preis which is being given to outstanding junior researchers in mathematics, informatics and natural sciences (2013). In addition, she has received an ERC Starting Grant of € 1.499 million for her ASTROROT-Project (2015).

PORTRAYING NEW CUI PROFESSORS

ARWEN PEARSON WOULD LIKE TO DEVELOP METHODS THAT EVERY BIOLOGIST CAN USE

The course for Prof. Arwen Pearson's career was set in Augsburg: During a school exchange in grade 11, the young Englishwoman heard for the first time of differential and integral calculus – methods that weren't taught before upper school in England – and suddenly large parts of physics became clear. "I loved it," the CUI professor says, and she decided not to become chief editor anymore but a scientist.

Three thesis supervisors and a mentor supported her intention. When Carrie M. Wilmot had listened to a talk by Pearson at a conference on crystallography, she convinced the young scientist to join her at the University of Minnesota. Pearson: "Friends warned me about the cold in Minnesota, but I spent five great years there. Carrie Wilmot was a fantastic role model and a very good mentor."

After her time in Minnesota, Pearson went back to the University of Leeds in England for a further eight years. As a junior professor at the Astbury Centre for Structural Molecular Biology, she built up a new group for method development: "This was a wonderful place for me with 50 research groups from physics, biology and chemistry. There were very good teams in biology that dealt with highly interesting issues and demanded the corresponding method development in my group – this always helped us on."

Still, easy access to large facilities was missing in Leeds. "I am very interested in the development of XFEL and other large facilities at DESY," the scientist says. "Hamburg offers me opportunities that would have been difficult in England. Thanks to the time in this high-ranking program in Leeds I have got a very solid network of biological collaborations. So my friends from biology also profit from the facilities in Hamburg."

Since May 2014 Arwen Pearson does research at the CUI in the field of biophysics and investigates biological processes on a molecular level with the help of time resolved crystallography and spectroscopy. The aim is to create a dynamical model of biology and to develop a widely applicable set of methods that can be used by every biologist. ■

HENNING TIDOW LIKES CHALLENGES

More internationality is nearly impossible: Between 2008 and 2013, Prof. Henning Tidow worked in England and Denmark. His Argentinian wife remained at first in England, but moved to Aarhus in 2010, where their daughter learned to speak fluent Danish in kindergarten. At home the family speaks English and Spanish, and since they moved to Hamburg German has gained importance.

Since March 2014 Tidow is leading a CUI working group in the field of biochemistry dealing with research on proteins tied to membranes. During his school years, he was particularly interested in mathematics and physics, but then decided to study biochemistry in Bayreuth. Tidow: "Biochemistry covers parts of everything, and in Bayreuth they have a strong focus on structural biology. I really liked that a lot." After one year in San Diego and a diploma from Bayreuth the scientist did his PhD on soluble molecules in Cambridge, UK, and then went to Trinity College as a Junior Research Fellow. "That was a scientific paradise. Thanks to the fellowship I was completely independent and could do whatever I wanted to," the scientist remembers. In the following period as a postdoc in Aarhus he discovered his interest in membrane proteins and crystallography.

Tidow's recent research is highly interdisciplinary – a combination of biochemistry, structure biology and applied physics. The working group is composed accordingly: a physicist, a chemist, a biologist. "I don't think much of scientists who only cover a part of the research chain and are too specialized. Ideally, PhDs run through the whole process from cloning, expressing, purifying, crystallization to structure analysis," the junior professor says. The work focuses on calcium transporters and calcium channels. Tidow: "The calcium pump for example is relevant for deafness. We know about this because there are certain mutations associated with hardness of hearing." The results of the fundamental research could possibly be useful for drug development.

Tidow likes to try out new things, to do things nobody did before: "There are more than 100,000 known soluble protein structures and only just below 1,000 membrane protein structures. It would be very interesting to take one step further in research and to observe how soluble proteins interact with membrane proteins." This step that connects both kinds requires the application of different crystallization processes – a challenge the scientist would like to accept. ■

MARTIN TREBBIN'S RESEARCH IS BASED ON NETWORKING

On the one hand, science has a target - but on the other hand, there is always something to discover. That is what makes it exciting because you never know exactly what to expect behind the next corner," Prof. Martin Trebbin says. Since autumn 2014 the chemist from Hamburg has been doing research as one of the six new CUI professors. His area of expertise is the investigation of structures in fluids, where the 32-year-old combines methods of microfluidics and X-ray scattering – thus working exactly at the interface of physics and chemistry.

Trebbin: "I fancied natural science very early on, and I especially wanted to do experiments in the laboratory." Parallel to his high school training in Hamburg, he became a chemistry technician and thus was familiar with chemistry in the laboratory quite early. During civil alternative service in a facility for the handicapped there was some time to reflect on what he would eventually do, but basically Trebbin knew exactly what he wanted: to study chemistry. The first published research study was performed during his Erasmus term in Oslo. At that time he was still focused on organic synthesis, even though his diploma thesis with Prof. Stephan Förster already dealt with microfluidics. In 2010 Trebbin followed his supervisor to the University of Bayreuth and completed his PhD in 2013 which centered on the combination of microfluidics and Röntgen radiation.

In Bayreuth his research was focused on the development of microchips for experiments with high intensity X-ray sources. These chips can be used to generate an extremely tenuous fluid jet – about 20 times thinner than a human hair. The transparent plastic chip is about the size of a 1-cent-coin and includes a very fine system of microchannels and a small nozzle. These fine structures make it possible to produce fluid jets on a micro meter scale for the smallest assays. Hence, this technology is perfectly appropriate for the research with proteins and nanoparticles at high intensive x-ray sources. "The micro-chip has the potential to accelerate the systematic implementation of nano-crystallography. Thus, the structure and dynamics of important biomolecules can be analyzed with high precision", the junior professor explains. The results might be of great interest for medical technology and also for the textile industry. The chip can be used to produce extremely thin fibers as a basis for elastic and tear-proof texture structures.

At the moment he is focusing on the formation of his group. "The foundation of a university working group is similar to founding a start-up. The group of Stephan Förster from Bayreuth is my role model, because there, excellent research meets a fantastic atmosphere among the people."

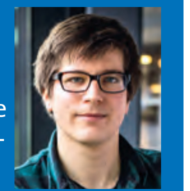
The "TrebbinLab" will offer many thematic linkages for the local research groups: "Microfluidics is located between physics, chemistry, biology and engineering science. It is like a large toolbox containing tools for controlling reactions and assays precisely and for analyzing them systematically," Trebbin explains. In the context of this kind of research networking is quite important: "I am already in close contact with the colleagues from European XFEL so that we can integrate this technology as early as possible." Furthermore, he cooperates with Prof. Gerhard Grübel (DESY) and Prof. Henry Chapman (Universität Hamburg, DESY) and maintains close contact to the Institute for Nanostructure and Solid State Physics (INF) and the Institute of Physical Chemistry. Trebbin: "The colleagues here in Hamburg are in favor of co-operations. I am very grateful that I – being a young scientist – am welcomed with such open arms." ■

Honors and Awards II.

Dr. Christian Kränkel (Universität Hamburg) has been awarded the Outstanding Reviewer Award of the Optical Society of America (OSA) (2014).

Prof. Alexander Lichtenstein (Universität Hamburg) has received the Max-Born-Preis 2014 from the British Institute of Physics and the Deutsche Physikalische Gesellschaft for his research on the theory of magnetism and electron correlations in condensed matter. In addition, Prof. Alexander Lichtenstein has been awarded the Ernst Mach-Ehrenmedaille 2015 by the Academy of Sciences of the Czech Republic.

Prof. Horst Weller (Universität Hamburg) is among the world's most influential scientific minds, as compiled by the publisher Thomson Reuters on the basis of several online citation databases (2014).



Dr. Philipp Wessels (Universität Hamburg) has received a second prize of the Deutscher Studienpreis awarded by the Körber Foundation for his dissertation on "Live images from the nanocosmos – Ultrafast magnetization processes of smallest structures in slow motion".

Prof. Dr. Andrea Cavalleri (Max Planck Institute for the Structure and Dynamics of Matter) receives the Max-Born-Preis 2015 for his „time-resolved measurements of photoinduced phase transitions in correlated electronic materials."

Honors and Awards III.

For his pioneering work in the development of femtosecond crystallography, **Prof Henry Chapman** (Universität Hamburg, DESY) receives one of the prestigious Gottfried Wilhelm Leibniz-Preise 2015 from the German Research Foundation (DFG). This most important German research award includes prize money of € 2.5 million.

The American Chemical Society honors **Prof. R. J. Dwayne Miller** (Max Planck Institute for the Structure and Dynamics of Matter) with the E. Bright Wilson Award 2015. In addition, Miller was awarded a Canadian Institute for Advanced Research Program: „Molecular Architecture of Life" was one of the top four awarded programs from a global call for new ideas out of over 260 vetted proposals from all fields including humanities and law. Last but not least Miller was inducted in the Optical Society (OSA) as a Fellow (2014).

Prof. Michael Potthoff (Universität Hamburg) has been appointed as Outstanding Referee by the American Physical Society (2015).

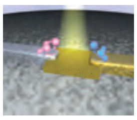
Prof. Robin Santra (Universität Hamburg, DESY) has been announced as Fellow of the American Physical Society (2015).

Prof. Klaus Sengstock (Universität Hamburg) has been announced as Fellow of the American Physical Society (2015). Moreover: The collaborative research project, SFB 925, of Universität Hamburg will be supported by the German Research Foundation for another four years from 1 July 2015 on. SFB speaker and head of the Institute of Laser Physics, Prof. Klaus Sengstock, says: „More than 100 scientists work together excellently in the SFB team. During this year's "Year of Light" and afterwards, we want to deliver fundamental contributions to understanding the interaction of light and material, and we are very much looking forward to new creative ideas and discussions."

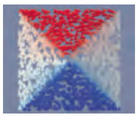
This year's Women's Advancement Award of Universität Hamburg is being bestowed upon the equal opportunity team in the Faculty of Mathematics, Informatics and Natural Sciences (MIN). CUI equal opportunity officer **Marie Lutz** is part of the team, which receives € 10,000 for establishing broad structural measures for advancing women (2015).

OUR COVER (clockwise)

GIANT RYDBERG MOLECULES – A successful combination of theoretical and experimental physics (Prof. Peter Schmelcher, Universität Hamburg, Prof. Tilmann Pfau, Universität Stuttgart): The illustration demonstrates the electron structure of an ultralong-range molecule. The existence of the so called Rydberg molecule had first been predicted a few years ago, before it was finally experimentally proven in ultracold atoms. DOI:10.1103/PhysRevLett.112.143008



PATTERN OF A SOLAR CELL – A group headed by Dr. Christian Klinke (Universität Hamburg) has now successfully used lead sulfide to create two-dimensional nanocrystals of variable density and demonstrated their suitability for use in solar cells. Lead sulfide is a semiconductor which can transform light into electric currents. The structure's small height leads to quantum effects that influence their optical and electrical properties. So the characteristics can be accurately adjusted to the desired application. DOI:10.1039/C4NR06957A



MAGNETIC VORTEX CORE – A group of scientists including Dr. Philipp Wessels (Universität Hamburg) filmed one of the candidates for the magnetic data storage devices of the future in action. The film was taken using an X-ray microscope and shows magnetic vortices being formed in ultrafast memory cells. The scientists used tiny squares of a nickel-iron alloy, each having four magnetic regions, whose magnetic field varies either in a clockwise or anti-clockwise direction. The individual magnetic domains are triangular, with their apexes meeting in the center of the storage cell. DOI:10.1103/PhysRevB.90.184417

BOILING WATER – The illustration is a result of Pankaj K. Mishra's PhD thesis, which the scientist from the CFEL-DESY theory division worked out in cooperation with Dr. Oriol Vendrell (DESY) and Prof. Robin Santra (DESY, Universität Hamburg). It shows a novel way of boiling water by as much as 600 degrees Celsius in less than a trillionth of a second. This would make the technique the fastest water-heating method on earth. DOI: 10.1002/anie.201305991

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