CFEL REPORT 2009/2010

CFEL
SCIENCE

Cover picture: rendering of the new CFEL research complex by hammeskrause architekten – for further information see also page 10.

TABLE OF CONTENTS

CFEL – A NOVEL ENTERPRISE USING REVOLUTIONARY LIGHT-SOURCES: MOTIVATION AND START-UP PHASE

JOCHEN SCHNEIDER, JOACHIM ULLRICH, WILFRIED WURTH

SINCE THEIR DISCOVERY IN 1895 BY WILHELM CONRAD RÖNTGEN, X-RAYS HAVE PLAYED A CRUCIAL ROLE IN ESSENTIALLY ALL AREAS OF BASIC AND APPLIED SCIENCE WITH TREMENDOUS IMPACT ON BIOLOGY AND MEDICINE.

Twenty Nobel Prizes in Physics, Chemistry and Medicine have been awarded for studies with X-rays, starting with W.C. Röntgen's first Prize in Physics in 1901. Up to the present day and with ever-increasing impact, imaging and investigations of structural and electronic properties of matter have remained of prime interest for forefront research and applications in physics, chemistry and biology.

After the first observation of "synchrotron" radiation in 1947, progress over the past 60 years has very much been driven by the enormous gain in brilliance of synchrotron radiation provided by electron storage rings, allowing for exciting views into the structure of matter. Here, most frontline X-ray studies explore static, i.e. time independent, ground-state properties of complex systems including large molecular machines that are of paramount importance for biology. Recently developed next-generation accelerator based light sources, the X-ray Free-Electron Lasers (XFEL), surpass the peak brilliance of state-of-the-art electron storage rings by one billion at pulse durations of about 1 to 300 fs, which is up to ten thousand times shorter than what is presently available. Moreover, the light is fully coherent along the lateral directions and partially along the longitudinal direction enabling innovative imaging schemes. Beams of adjustable wavelength are provided in sequences of ultrashort pulses containing about 10^{12} photons each. By comparison, a full second is necessary to get this many photons from today's best synchrotron radiation facilities. Therefore, this is a groundbreaking revolution in X-ray science.

The gain in peak brilliance, along with the ultrashort duration of the light-flashes, allows scientists, for the first time, to study the dynamics of complex systems with atomic resolution in space and time. Thus, this new era in science will be characterized by taking "movies" instead of "pictures", by exploring "dynamics and function" instead of "static structure". The goal is to understand and ultimately control the "functioning" of matter, of biological systems and drugs, of correlated materials, of chemical reactions or of nanostructures.

In December 2003, after the decision by the German Federal Government to realize the X-ray FEL proposed by DESY as a European project, DESY submitted the vision of a Center for Free-Electron Laser Science (CFEL) for strategic evaluation by the Helmholtz Association of National Research Centers (HGF). In October 2004 the Helmholtz Senate strongly recommended to strengthen DESY's photon science in-house research through CFEL. This should serve as an anchor point for the preparation of the scientific programs at the Vacuum Ultraviolet Free-Electron Laser (VUV-FEL) and the planned European XFEL Laboratory.

At the same time, based on a memorandum to exploit the new challenges posed by XFELs in 2003, the "Perspective Commission" of the Max Planck Society (MPG) recommended entering this innovative field of science in May 2004. Supported by the President's "Innovation Fond" since 2005, scientists from several Max Planck Institutes have performed pioneering experiments at FELs. Further deliberations led to a recommendation by both the Chemical, Physical and Technical Section as well as the Biological and Medical Sections of the MPG. They advised to establish an interdisciplinary "Max Planck Research Group" together with the University of Hamburg at DESY, including an "Advanced Study Group".

The concept of a Max Planck Research Group at the University of Hamburg materialized in 2007 with the joint signature of a cooperation contract between the University of Hamburg and the Max Planck Society. In the beginning of the same year, the FEL research activities of several Max Planck Institutes had been joined to form the Advanced Study Group, acting as a key link for future Max Planck FEL activities from all other departments. Following this example, the University of Hamburg decided to concentrate its involvement in FEL research in a second Advanced Study Group.

In 2007, these parallel activities were merged. DESY, the Max Planck Society, the University and the City of Hamburg signed a collaboration contract on the establishment and operation of the Center for Free-Electron Laser Science. CFEL, acting across the classical scientific disciplines and, for the first time, across German Science Organizations, was envisioned to provide a novel platform for transforming the technology-driven "X-ray revolution" into a revolution in science and applications at the frontiers of knowledge. CFEL integrates the scientific activities and the expertise in different fields of all founding partners in a coordinated and synergetic effort to create a world-leading center in the field of Free-Electron Laser Science.

The organizational chart of CFEL includes several departments and junior research groups provided by the partner organizations DESY, University of Hamburg, and Max Planck Society. DESY is in charge of two experimental and one theory division plus one junior research group. The Max Planck Society and the University of Hamburg jointly support two experimental divisions with three junior research groups. In addition, both institutions operate Advanced Study Groups with two and three junior groups, respectively. Each of the CFEL partner organizations promotes the research and development of high-performance radiation/X-ray detectors. The City of Hamburg is building the CFEL Office and Laboratory Complex.

Advised by a Foundation Committee, CFEL was able to attract and appoint leading scientists from all over the world in a highly competitive environment, such that all five divisions and many junior research groups have become fully operational within only three years. CFEL scientists contribute to highest-level teaching and training of students at the University of Hamburg within a DFG-funded Research Training Group and an International Max Planck Research School.

This report introduces the Center for Free-Electron Laser Science and summarizes the exciting results achieved by CFEL researchers in only a few years since its foundation. Many of the results exploit and build on the synergies between the different groups. Upon evaluation in spring 2011, the Max Planck contribution to CFEL is envisioned to emerge into a full-fledged Institute with four divisions and the Advanced Study Group such that CFEL will be well prepared to meet the challenges of the "X-ray revolution" in the future.

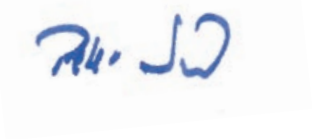
CFEL – PARTNERS

PROF. DR. PETER GRUSS
PRESIDENT OF THE MAX PLANCK SOCIETY

Prof. Dr. Peter Gruss

"Together we are strong" - the Center for Free-Electron Laser Science (CFEL) is a wonderful illustration of the truth of this saying. The scientific success of CFEL is testimony to the farsightedness of an initiative that was launched as a cross-institutional scheme nearly 10 years ago. This was the time that saw a global, burgeoning interest in conceptualising and developing X-ray free-electron lasers (FEL), such as the European XFEL in Hamburg, the Linear Coherent Light Source LCLS in Stanford, as well as a corresponding device in Japan. The wave of research into FELs at the time provided Max Planck scientists with the impetus to reflect on the potential of such large-scale scientific equipment for basic research in the Max Planck Society (MPG). The relevant deliberations led to a participation in the CFEL in form of a Max Planck Research Group at the University of Hamburg and of an Advanced Study Group of the Max Planck Society with the involvement of scientists of several MPIs. It also became apparent that an efficient and optimal use of FELs could be best realised in close cooperation with other research organisations. For me, CFEL is thus a successful example for those synergies resulting from the close collaboration of partners with complementary expertise. In this respect, the close ties that the Max Planck Society has forged with universities over the years have paid off; ties that did not only result in joint appointments at CFEL, but also in a graduate school which is currently in the process of being established. The International Max Planck Research School for Ultrafast Imaging and Structural Dynamics at the University of Hamburg is dedicated to providing a structured training programme for junior researchers, offering excellent framework conditions for independent research and interdisciplinary PhD projects.

From the point of view of the Max Planck Society, CFEL is a first-class strategic investment in the future of the research and technology landscape in Hamburg and its environs. It is to be expected that the key technology "photonics" will attract numerous high-tech companies to Hamburg as a site of thriving research, initiating an intensive transfer of knowledge into applications. I wish the scientists at CFEL continuing success and hope they will always have sufficient photons with the required properties in their experiments!



PROF. DR. DIETER LENZEN
PRESIDENT OF THE UNIVERSITY OF HAMBURG

Prof. Dr. Dieter Lenzen

The University of Hamburg took the unique opportunity to cooperate with two excellent external research organizations that opened up with the joint foundation of the CFEL with the partners DESY, Max Planck Society and the Free and Hanseatic City of Hamburg.

The excellence cluster of physics of the University of Hamburg is profiting already in research, education and young talent support from the research network established in CFEL. This network pools the activities in science related to free-electron lasers and allowed the university and its partners to recruit renowned researchers with excellent reputations from all over the world. It allowed the University of Hamburg, in cooperation with its excellent partners, to sharpen the University's profile in research with and at the next generation light sources. First visible successes are the funding of Hamburg's Excellence Cluster "Frontiers in Quantum Photon Science", an international Max Planck Graduate School, a DFG Graduate School and the cooperation with Hamburg School for Structure and Dynamics in Infection. Further proposals for a DFG Collaborative Research Center and a cluster of excellence within the Federal German Excellence Initiative are in preparation.

The local and scientific proximity to the European XFEL project opens world wide the best opportunities for CFEL's young talents and its established researchers of the University of Hamburg. These opportunities will additionally increase when the construction of the new CFEL research center is finished. These most modern laboratories and office spaces became possible due to the generous support of the Free and Hanseatic City of Hamburg and will further enhance the attractiveness of the University of Hamburg.

PROF. DR. HELMUT DOSCH
CHAIRMAN OF THE BOARD OF DIRECTORS OF DESY

Prof. Dr. Helmut Dosch

When CFEL has been founded the three partners - the University of Hamburg, Max Planck Society and DESY - had bold visions on the future challenges and revolutionary opportunities offered by the novel X-ray laser light. Today, I can proudly say, that CFEL has made tremendous progress to realize the vision to become the world-leading center for FEL research. Already today, CFEL is a world-wide applauded structure for top-notch research.

The year 2010 has been a particularly successful year for CFEL. Dwayne Miller who joined CFEL coming from Toronto University has successfully launched his research activities. It has been fascinating to observe how fast the new Relativistic Electron Gun for Atomic Exploration (REGAE) facility has been built up. I am particularly grateful to the DESY accelerator team for the most efficient cooperation with the CFEL team. Also in 2010, Robin Santra from Argonne National Lab/University of Chicago has started to build up the theory department within CFEL. Robin, an internationally renowned scientist in the theory of ultrafast phenomena, will develop the theory roof of CFEL. To add to the 2010 success story, we could attract Franz X. Kärtner from the Massachusetts Institute of Technology (MIT). Franz, who will start on Jan 1, 2011 at CFEL, will bring the indispensable laser technology to CFEL. His expertise in optical lasers, attosecond-photonics, attosecond-science (High Harmonic Generation (HHG) for seeding and spectroscopy) and laser acceleration will boost the full potential of the FEL facilities.
The smooth and most successful cooperation between three partners under the CFEL roof is an excellent example of successful cooperation between the three different pillars of the German scientific landscape. With the successful appointments over the last two years CFEL has all leading scientists on board. In 2011, the Max Planck Society will have an in-depth evaluation of the CFEL achievements and its future visions. I am very optimistic that this exercise will most positively influence the decision on a new Max Planck Institute to be founded within the CFEL umbrella.
Moreover, the CFEL building now slowly takes on shape. We are quite positive that the CFEL scientists can move into the new offices and labs in 2012. We are looking forward to the next years of CFEL which will be full of discoveries and advancements of FEL science and laser technology.

I warmly thank the many committed collaborators at CFEL for their impressive work during these years.

DR. HERLIND GUNDELACH
HAMBURG'S SENATOR FOR SCIENCE AND RESEARCH

Dr. Herlind Gundelach

A research and science location must concentrate on its strengths and identify the nationally and internationally competitive topics strategically suitable as a basis for further development using this potential. Therefore the Senate of the City of Hamburg decided to strongly support physics in cooperation with the best partners in Germany. The aim is to create a leading cluster of excellence in structure research in Germany and Europe. At the same time the Senate aims to intensify the networking between universities and external research organizations under a single roof. In this sense not only the dividing borders between the disciplines but also the borders between states and countries will be overcome to create truly free science at its best.

CFEL is an excellent role model for this purpose. Uniting the specialized competences across classical borders of departments it establishes a striking and unique cooperation between DESY, Max Planck Society and the University of Hamburg. I am very glad that the expectations regarding its reputation and scientific results have exceeded all expectations in the first years and that we are able to draw a positive interim balance. The scientific success is based mainly on the successful recruitment of renowned researchers with excellent reputations from all over the world. These results clearly demonstrate that CFEL offers the best opportunities to perform outstanding research with and at free-electron lasers. Hamburg's CFEL is developing into the world's leading competence center for research with the next generation light sources.

Not by chance is CFEL already a scientific success story. This success is the result of the hard, committed and creative work of all involved scientists and science managers.

In July 2010, we celebrated the topping out for the new building which will start operating officially in spring 2012. I am very certain that there are no obstacles for the future development of CFEL to a research center for highest-quality structure research. For the future I wish all parties concerned pleasure and success at their work.

CFEL – A LIGHTHOUSE FOR SCIENCE

HAMMESKRAUSE ARCHITECTS

At the Center for Free-Electron Laser Science in Hamburg, an international focal point is being established for basic research at and with free-electron lasers. The center represents the first cooperative endeavor between the University of Hamburg, the Max Planck Society and the Deutsches Elektronen-Synchrotron (DESY) for the purpose of developing a shared building. One of our first concerns when launching the project was to find out in conversations with the directors in charge at the three independent research institutions how the scientists in the various groups intended to collaborate, what kind of "spirit" the building should manifest, and which architectural environment might best support the diverse work processes.

Both elevated laboratories and vibration-isolated physical measuring rooms were called for, as well as offices and conference rooms. The demands placed on the structural dynamics of rooms for working with free-electron lasers are extremely high, which made it expedient for several reasons to arrange these rooms together on the ground floor. The experiments furthermore require shielded working conditions, which made it very important to put the scientists in close proximity to the areas for joint utilization, thus conjoining theoretical and experimental activities.

In order to generate a high level of synergies between the various research groups, areas between the rooms have been opened up to promote communication. Above a one-story structure set aside for experimental work rise three office floors in the form of a rotunda containing rooms offering a variety of different layouts. Along with cubicle offices, there are also combi-zones, tea kitchens and conference rooms spread throughout the atrium spaces. The central atrium serves the purposes of communication and knowledge transfer, connecting the various functional areas over four floors. The ground floor contains all experiment areas, the seminar rooms and a cafeteria, arranged around the light-filled entrance hall and two central garden courts.

The ground floor with its laboratories and the office floors located above are distinguished both formally and thematically. Their design and outward appearance convey the contrast between the laboratory versus the office function. In thematic terms, the ground-floor level forms a solid and closed base for the rotunda element. The self-contained solidity of the base is underlined by its almost complete lack of windows and an exterior cladding of narrow bricks. Diametrically opposed to this handling, the three office floors have been given a light and transparent facade with linear bands of windows, which emphasizes the roundness of the structure. The character of the atrium is shaped mainly by the free-form skylight above. This consists of a filigree steel grid supporting multi-layered cushions of translucent ETFE (ethylene tetrafluoroethylene), supplying the building with a bright and lightweight crowning element.

hammeskrause architekten

CFEL – ACROSS THE DISCIPLINES

The Center for Free-Electron Laser Science (CFEL) is a joint research collaboration among three institutions: Deutsches Elektronen-Synchrotron (DESY), the Max Planck Society (MPG), and the University of Hamburg (UHH). CFEL consists of seven divisions as depicted in the "CFEL House Sketch" in Figure 1. In the center are the five core divisions surrounded by the two pillars of the Advanced Study Groups (ASGs).

Three core divisions are supported by DESY (marked in blue): the "CFEL Theory Division" led by Robin Santra (see also page 24), the "Ultrafast Optics & X-rays Division" under the leadership of Franz X. Kärtner (see also page 26), and the "Coherent Imaging Division" led by Henry Chapman (see also page 14 and 32). Within this last division an independent junior research group has been established. It is led by Jochen Küpper and focuses on "Controlled Molecule Imaging" (see also page 16).

Two core divisions are jointly supported by the MPG, the Free and Hanseatic City of Hamburg, and the UHH. They form the Max Planck Research Department for Structural Dynamics (MPSD) at the University of Hamburg (marked in green&red): the "Condensed Matter Dynamics Division" led by Andrea Cavalleri (see also page 18 and 36), and the "Atomically Resolved Dynamics Division" under the leadership of R. J. Dwayne Miller (see also page 22 and 40). In the latter division an independent junior research group will be initiated by Nils Huse starting in early 2011. Adrian Cavalieri's independent junior research group on "Extreme Timescales" within the Condensed Matter Dynamics Division is already fully operational (see also page 20).

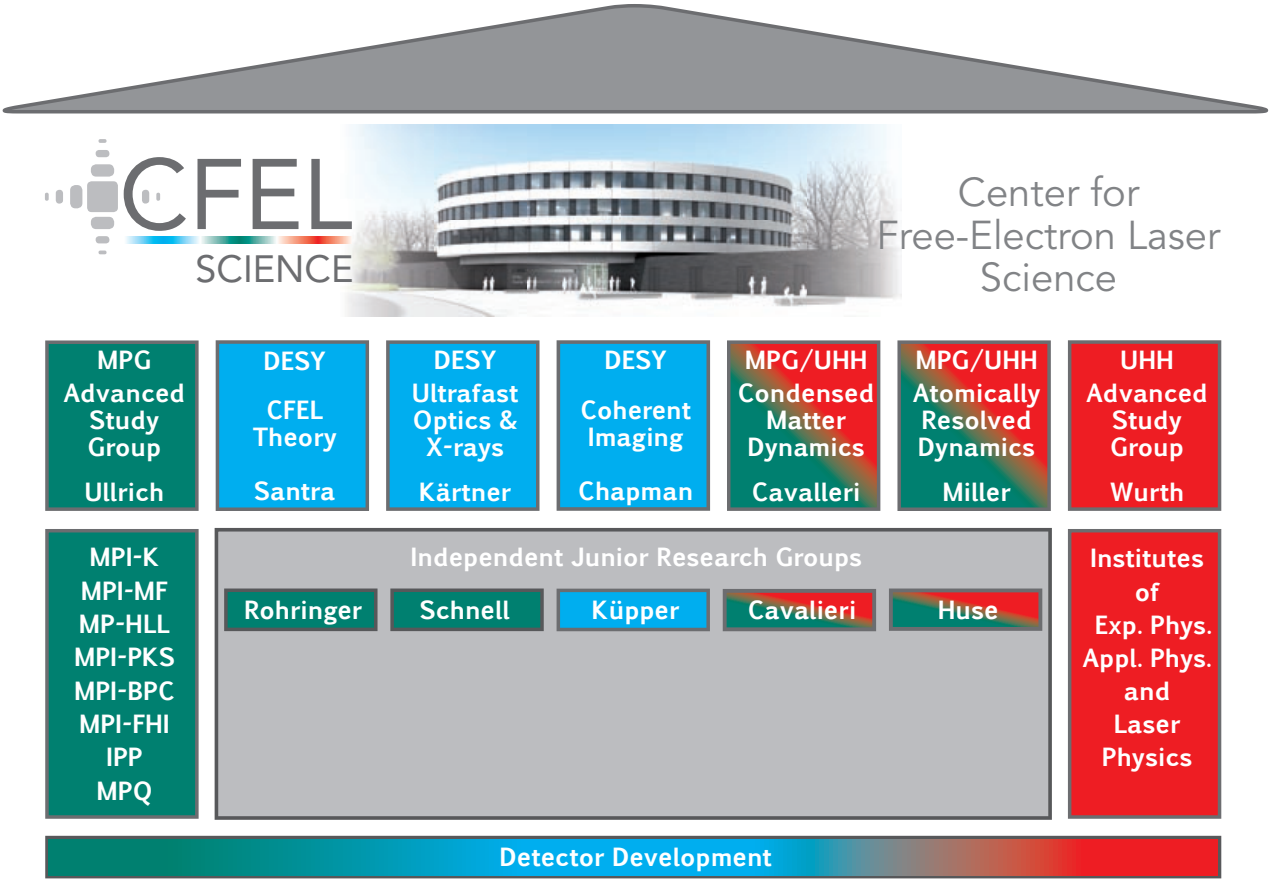


Figure 1: CFEL House – A brief chart of the organizational (not financial) structure of the groups and institutions that are joining forces in the Center for Free-Electron Laser Science in Hamburg.

Figure 2: Interim buildings (49 & 49a) for the CFEL Core Divisions with offices and laboratories.

The ASGs comprise the University of Hamburg Advanced Study Group (UHH-ASG in red) led by Wilfried Wurth (see also page 30 and 49), Spokesperson of the BMBF Priority Program FSP-301 "FLASH: Matter in the light of ultrashort and extremely intense X-ray pulses" and the Max Planck Advanced Study Group (MPG-ASG in green) led by Joachim Ullrich (see also page 28 and 44), Director at the Max Planck Institute for Nuclear Physics Heidelberg (MPI-K). The ASGs are designed to focus and support the strong activities in FEL science that started in both organizations prior to the foundation of CFEL and to act as a nucleus for emerging interdisciplinary science within their respective organizations in research fields where the problem solving potential of FEL technology and science is not yet fully exploited.

The UHH-ASG consists at the present time of groups from the Institutes of Experimental Physics, Laser Physics and Applied Physics of the Physics Department within the Faculty of Mathematics, Informatics and Natural Sciences. To further enhance the UHH-ASG activities within CFEL hiring of the heads of up to three independent junior research groups is currently in progress.

The MPG-ASG consists of a central group of researchers located at Hamburg as well as of scientists from various Max Planck Institutes (MPIs) with prime interest in FEL science and is managed by a Steering Committee. Scientists, students, and technicians residing directly in Hamburg (MPG-ASG Hamburg) form the heart of the ASG supporting and assisting the FEL-related efforts of individual MPIs. The MPG-ASG Hamburg was recently strengthened by establishing the two independent junior research groups led by Melanie Schnell and Nina Rohringer. Presently eight Max Planck Institutes all over Germany collaborate within the MPG-ASG:
Max Planck Institute for Nuclear Physics (MPI-K) and for Medical Research (MPI-MF), both in Heidelberg, for the Physics of Complex Systems in Dresden (MPI-PKS), for Biophysical Chemistry in Göttingen (MPI-BPC), for Plasma Physics (IPP), of Quantum Optics (MPQ), both in Garching, the Fritz Haber Institute of the Max Planck Society in Berlin (MPI-FHI), and the Max Planck Halbleiterlabor (German for semiconductor laboratory) in Munich (MP-HLL).

CFEL is led by the division directors and the heads of the Advanced Study Groups, jointly constituting the CFEL Management Board, with Joachim Ullrich acting as its present Chair, assisted by the Research Coordinator, Ralf Köhn. During the foundation phase the Management Board was assisted and advised by the Foundation Commission which will be followed by a Scientific Advisory Board as soon as steady-state operation is approached.

COHERENT IMAGING DIVISION

DIVISION LEADER PROF. DR. HENRY CHAPMAN

Prof. Dr. H. Chapman

Understanding the processes in the living cell requires deducing the functions of its molecular machinery from both static and dynamic three-dimensional images of those machines. Determining the molecular function usually requires imaging or uncovering the structure at the resolution of the constituent atoms. Such knowledge allows a "bottom up" view of the organization and processes of life, providing valuable insights into disease and drug design. X-ray crystallography has provided most of the macromolecular structures determined to date. This method amplifies the scattering from a single molecule by the coherent addition of billions of their repeats in a regular lattice. However, the need to crystallize proteins is a major bottleneck in structure determination, often taking decades of effort to grow crystals of adequate quality. "Single particle" imaging aims to sidestep the requirement for crystals, using the enormous intensity of X-ray free-electron laser pulses to make up for the loss of scattering strength. In many cases sub-micron "nanocrystals" may be readily obtained, which are too small or radiation sensitive for conventional synchrotron-based studies. One of the most significant classes of proteins, membrane-bound proteins, tends only to form two-dimensional crystals or 3D nanocrystals. Less than 300 membrane proteins have been solved to date, despite the fact that 60% of all drugs target these proteins. Femtosecond protein "nanocrystallography" marries single-particle X-ray FEL techniques with traditional crystallography, offering structural biology a high-throughput method to obtain structures without the need for time-consuming crystallization. Our method has opened up a new method of structure determination.

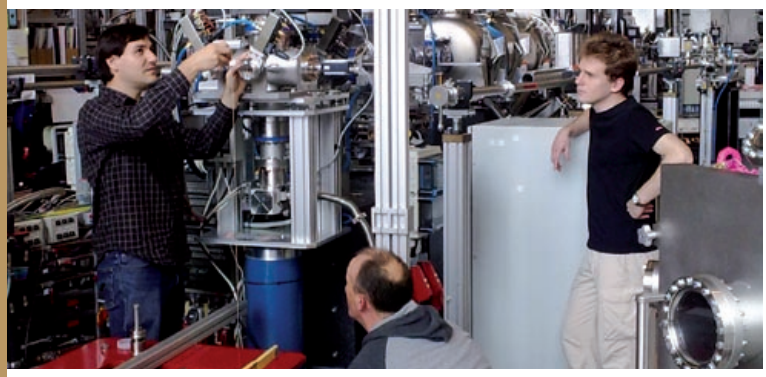


Figure 1: Group members preparing for experiments at the FLASH soft-X-ray FEL facility at DESY. From left to right: Andrew Aquila, Lars Gumprecht, and Karol Nass.

The CFEL Imaging Division is developing these methods of 3D imaging of identical biological objects using intense X-ray FEL pulses. This work can be characterized as pushing X-ray imaging beyond conventional limits. We overcome these limits on many fronts. In an X-ray microscope, the finest features that can be examined are usually limited by the quality and performance of the X-ray lens. Our methods are "lensless" techniques that invert an image from the coherent X-ray diffraction pattern of an object. In this case the finest resolution that can be achieved will then be limited by radiation damage to the sample: the ionizing X-ray radiation used to form the image causes changes to the very structure under examination, during the exposure. We have shown that even this limit can be overcome by outrunning the damage processes, by utilizing the ultra-short and ultra-intense pulses of X-ray free-electron lasers. Dubbed "diffraction before destruction," the X-ray FEL pulses are faster than the timescales of significant radiation damage so that the diffraction pattern represents the undamaged structure. We are also pushing these techniques to the fastest timescales, in the imaging of photo-induced processes that are synchronized to the X-ray probe pulse, and by diffraction of laser-aligned molecules. The group carries out experiments at synchrotron sources, such as the Swiss Light Source and Petra III, and the FLASH and LCLS FELs. The group has also contributed to the design of diffractive-imaging apparatus at the upcoming FERMI seeded soft-X-ray FEL, in Trieste, and will utilize this source for ultrafast time-resolved imaging experiments.

The ambitious goals of single particle and nanocrystallographic imaging require large technical advancements. We are taking part in a large international collaborative program to make the necessary improvements in X-ray focusing and compression, detectors, delivery and preparation of the molecular beam, data assembly, and phase retrieval techniques to obtain an image. Additionally, we are investigating the damage effects of X-ray pulses and methods to delay the onset of damage. We have led experimental campaigns at the FLASH and LCLS X-ray free-electron la-

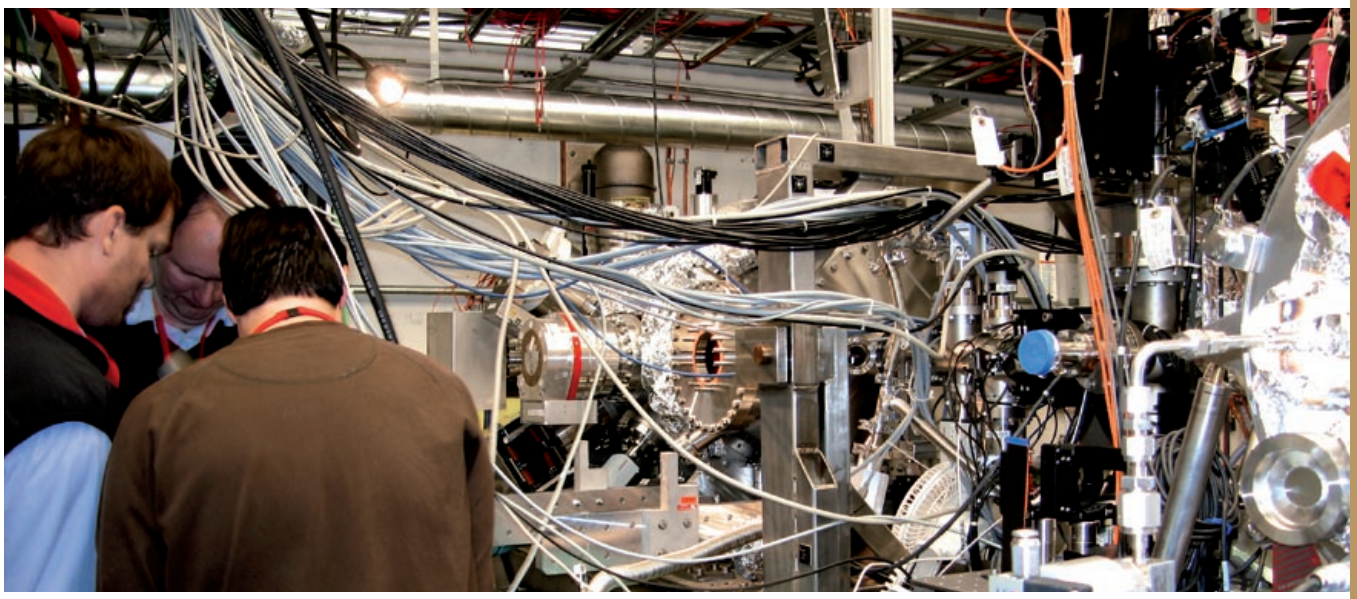


Figure 2: Anton Barty (left), Joachim Schulz (center), and Andrew Aquila (facing away) carrying out tests on the CFEL ASG CAMP instrument at the AMO beamline at LCLS, in preparation for coherent diffractive imaging measurements.

sers which have been key in driving the instrumentation and technological advances. Our first diffraction patterns of nanostructures, each recorded with a single 30-fs pulse, produced the fastest images ever made. We have applied this unique capability to create ultrafast stop-motion images of laser-induced processes, such as laser ablation, and for studying the interaction of the X-ray pulse with the sample itself. We have developed novel holographic methods to help phase diffraction patterns and to follow the time dependence of the X-ray interaction.

The group has developed a coherent diffractive imaging apparatus for soft-X-ray imaging at FLASH, carried out by Joachim Schulz, Holger Fleckenstein, and their colleagues. Diffraction patterns are recorded on moveable sets of CCD detectors, from single pulses scattering from nanostructures positioned in the beam, or from particles on the fly that are injected across the beam. This instrumentation has been used to optimize particle injection and collect single particle diffraction data to test assembly and phase retrieval algorithms. It is also being used for studies in warm dense matter and imaging the explosion of particles irradiated by FEL pulses, to determine conditions and strategies for highest-resolution imaging. The instrumentation efforts of the group also extend to liquid microjets and synchronized droplets, for nanocrystallography and solution scattering experiments, through the work of Daniel DePonte. Mengning Liang and Francesco Stellato have utilized these techniques to better characterize and prepare a wide range of nanoparticle systems for imaging and experiments on the effects of radiation damage. These experiments have led Anton Barty, Carl Caleman, and colleagues to the realization that the limits of imaging can more easily reach atomic resolution than previously thought.

Imaging experiments at X-ray FELs generate large volumes of data, with a typical week-long run yielding 50 TB of data. These data are processed on a new SGI 72-core computer cluster with 600 2TB hard-drives. Managing this volume of data is a large challenge, and the group, led by Anton Barty, develops specialized tools for data reduction, such as image recognition and “hit finding”. Nanocrystallography and single-particle imaging involves processing millions of diffraction patterns to create a single 3D dataset, and software tools have been developed by Thomas White and his colleagues to process these by customizing and improving upon traditional crystallographic software. The group actively develops phase retrieval algorithms, building upon iterative methods that recover phases based on real-space constraints, and extending to extracting single particle images from diffraction patterns of ensembles. Novel methods are under development by Andrew Martin. The group is also working on extending traditional crystallographic phasing techniques by taking advantage of the high spatial coherence of the X-ray pulses and their high intensities. Working with the CFEL Theory Division, phasing methods are being developed that capitalize on changes in atomic structure that are induced by the immense intensity of focused X-ray FEL pulses.

CONTROLLED MOLECULE IMAGING GROUP

GROUP LEADER PROF. DR. JOCHEN KÜPPER

Prof. Dr. J. Küpper

Progress in experimental physics is driven by the development of novel or improved experimental techniques and by the applications made possible by these advanced methods. In the Controlled Molecule Imaging Group we develop methods for the manipulation of complex neutral molecules in the gas phase. These methods, in turn, allow us to perform novel investigations of the molecules' structure and dynamics, aiming at a complete understanding of atomic and molecular processes that underlie chemistry and biology.

We use electric fields to manipulate the translational and rotational motion of large molecules. These experiments range, for example, from dc electric fields in the electric equivalent of the Stern-Gerlach deflector over switched electric fields in AC guides and decelerators to high-frequency laser fields for alignment and mixed field orientation of the molecules. We have demonstrated the quantum-state and conformer (structural isomer) selection, the alignment and orientation, and the deceleration of large and complex molecules in the gas phase. We have also been involved in experiments applying decelerated ammonia molecules in prototype experiments for spectroscopic purposes, in storage rings, and in micro-structured molecule-optics experiments.

Exploiting these control techniques we have demonstrated that the quantum-state-selected polar ensembles produced by our methods allow unprecedented degrees of alignment and orientation. We have demonstrated the feasibility to obtain molecular-frame photoelectron angular distributions in femtosecond experiments, providing a direct pathway to the making of the "molecular movie". Such state- and conformer-selected oriented ensembles are ideal samples for diffractive imaging studies of gas-phase molecules, for high-harmonic generation and tomographic imaging, for molecular-frame photoelectron-angular-distribution studies, for reactive scattering, and many other experiments in chemistry and physics.

At CFEL we are now setting up next-generation experiments to study the ultrafast dynamics of mass-, isomer- and quantum-state-selected complex molecules and molecular aggregates using various experimental techniques. We will investigate molecular-frame photo-electron-angular distributions from strong laser fields and from extreme ultraviolet (XUV) or X-ray lasers or X-ray and electron diffraction imaging. In parallel we develop cold beams of prototypical complex molecules, such as the "building blocks of life", peptides, and similar large molecules in order to apply our techniques to these interesting yet very complex samples. These experiments will allow us to investigate intra- and inter-molecular dynamics of complex molecules on fast and ultrafast timescales.

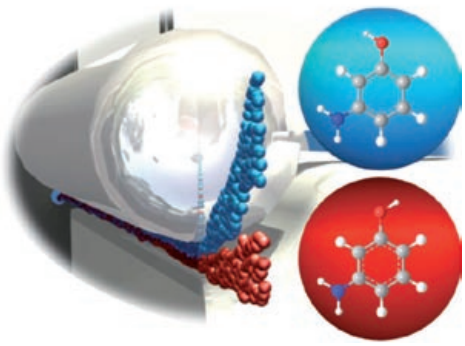


Figure 1: Controlled Molecule Imaging Group in the laboratory. From left to right: S. Stern, J. Küpper, S. Trippel, L. Holmegaard (left). Stereoisomers of complex molecules generally have distinct electric dipole moments for the same mass. The different dipole-moment-to-mass ratios can be exploited in the spatial separation of these species using electric fields. The pure samples thus created offer opportunities in isomer-specific and stereoselective investigations (right).

Bird's-eye view on the CFEL construction site from the south (September 2010).

CONDENSED MATTER DYNAMICS DIVISON

DIVISION LEADER PROF. ANDREA CAVALLERI

Prof. A. Cavalleri

Condensed matter research is concerned with the microscopic description of macroscopic phenomena in the solid state. Superconductivity, magnetism, metal-insulator transitions and many other phenomena of fundamental and applied interest are typically studied using a combination of microscopic techniques (X-ray diffraction, neutron scattering, scanning tunneling microscopy), and macroscopic probes (e.g. transport, magnetometry or optical spectroscopy), as well as by theory and material discovery. The great majority of these studies concentrate on equilibrium properties of solids, seeking to understand the ground state properties and their interaction with low-lying excitations.

Yet, most modern applications to devices require control of materials properties on the shortest length scales and the fastest timescales, situations in which matter is not in equilibrium, and conventional thermodynamics fails to capture its properties. In this division, we focus on the non-equilibrium properties of condensed matter, and on their control on the shortest timescales. On the one side, we seek to develop tools to steer solids in desired directions, developing sources in which for example sculpted THz pulses at high fields can be used to steer condensed matter in new directions. However, we are also taking advantage of the breathtaking developments of the past few years, making use of ultrafast probes over nearly seven orders of magnitude in wavelength (from the THz to the hard X-rays), which are used for scattering and spectroscopy. Further, we explore dynamics of solids on extreme timescales, reaching into the attosecond range. Free-electron lasers, a new revolutionary technology in photon science, feature in our research as a major enabling technology.

Figure 1: Condensed Matter Dynamics Division: Left to right: 1st row: A. Cavalleri, P. Johanssen, V. Khanna, M. Hoffmann, A. Cavalieri, D. Nicoletti, 2nd row: S. Tober, P. Popovich, I. Grguras, M. Petrich, F. Habenicht, A. Simoncig, J. Harms, 3rd row: C. Manzoni, M. Först, S. Lupi, R. Brodowski, S. Kaiser.

Dr. Stefan Kaiser: Spectroscopy of correlated electron systems

Understanding doped Mott insulators, materials that are at the border between bad metals and correlated electron insulators, is one of the key challenges in modern condensed matter physics. It is believed that these phases hold the secrets to understand and control high temperature superconductors. We study the dynamics of doped Mott insulators in materials systems that range from cuprate high Tc superconductors to organic salts. We use ultrafast techniques that range from THz and infrared optics to extreme ultraviolet (XUV) photo-electron spectroscopies.

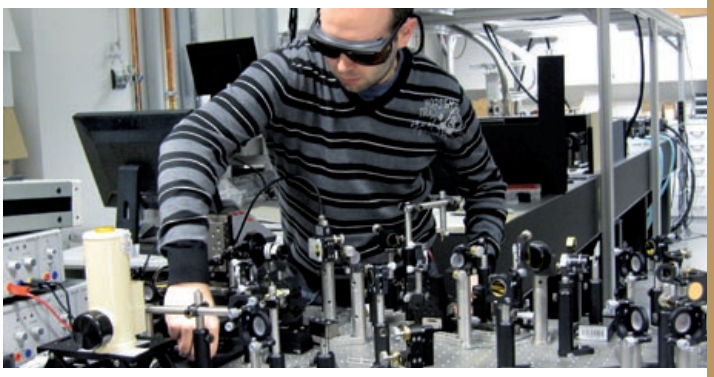


Figure 2: S. Kaiser enhancing the pump-probe spectroscopy setup to the MIR range to measure the photo-induced dynamics of the Mott-gap in correlated electron systems.

Dr. Matthias C. Hoffmann: Nonlinear THz science

Many collective excitations in strongly correlated condensed matter systems can be observed by optical spectroscopy in the terahertz (THz) range of the electromagnetic spectrum, at frequencies between 0.1 and 15 THz (3 and 500 cm^{-1}). However, until recently most radiation sources at these wavelengths have been too weak to allow manipulation of collective excitations by light. The nonlinear THz science subgroup led by Matthias C. Hoffmann is using newly developed intense table-top THz sources to study the behavior of correlated electron systems subjected to sub-picosecond electromagnetic pulses with high field strengths.

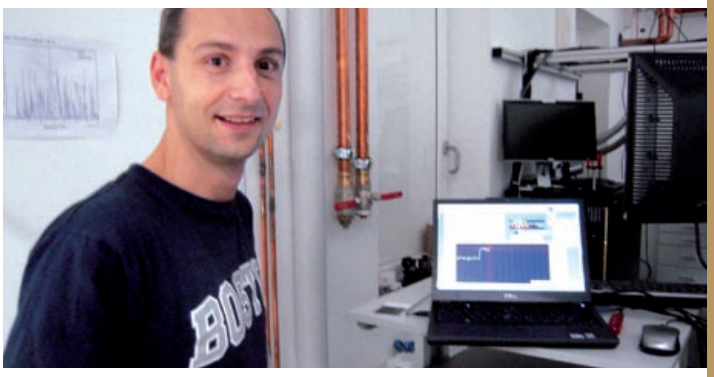


Figure 3: M. C. Hoffmann just found the IR-Pump/THz probe signal.

Dr. Michael Först: Materials control

To control the phase state of materials in a non-thermal fashion is one of the main goals in ultrafast condensed matter science. For example, we seek to manipulate complex electronic and magnetic states by coherent optical excitation of specific vibrational modes. In-house developed sources of few-cycle high-amplitude carrier-envelope phase-stable electric fields at mid-infrared wavelengths are key enabler of our investigations to identify nonlinear control mechanisms. We further exploit the potential of ultrafast resonant soft X-ray diffraction at free-electron lasers, to uncover transition pathways of the magnetic and electronic states.

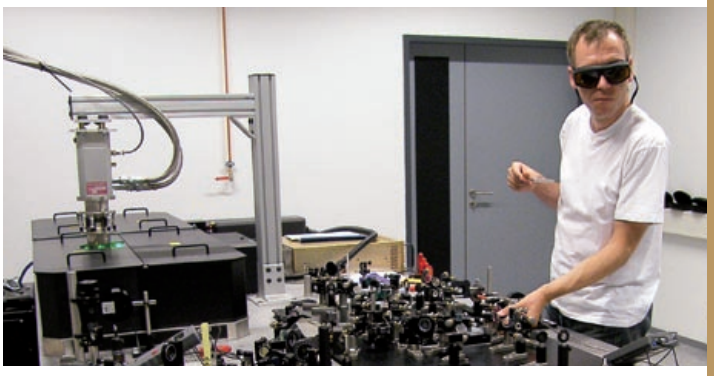


Figure 4: M. Först setting up a mid-infrared light source, comprising an optical parametric amplifier and difference-frequency mixing stage, that enables vibrational excitation of condensed matter.

EXTREME TIMESCALE GROUP

GROUP LEADER PROF. DR. ADRIAN L. CAVALIERI

Prof. Dr. A. Cavalieri

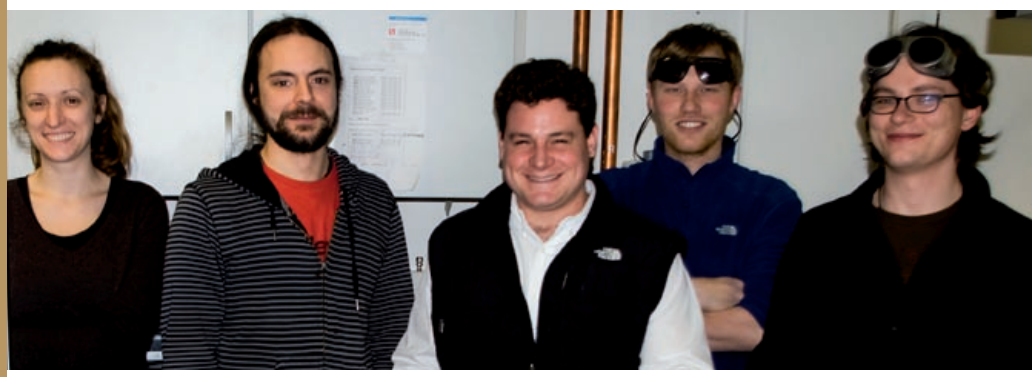
Attosecond spectroscopy was first extended to condensed matter systems in 2007 (A. L. Cavalieri, et. al. Nature, 2007). In this demonstration, sub-100-attosecond time resolution allowed relative escape times of photo-emitted electrons through a metal surface to be measured. While these first experiments focused on the observation of the elementary photoemission process, this result also established a route to probing stimulated and controlled dynamics on extreme timescales.

At CFEL, the range of available pump photon energies will be expanded beyond the XUV to include the THz, and deep UV, allowing for targeted excitation of complex, condensed matter systems. The key to this advance, is the application of single-cycle, NIR driving laser pulses, ideally suited for frequency conversion through nonlinear processes including three and four-wave mixing, optical rectification and through high-harmonic generation. Single-cycle drive pulses, comparable in energy and duration to the shortest optical laser pulses available in the world, are obtained at CFEL by tuning the temporal dispersion in an otherwise commercial multi-pass Ti:Sapphire amplifier system with the addition of customized chirped mirror multi-layer optics.

With this uniquely tunable source, we will probe subsequent dynamics in condensed matter systems using time-resolved, angularly-resolved photoemission and absorption spectroscopy. Rather than striving for the highest time-resolution alone, temporal and spectral resolution will be balanced to suit the problem at hand. In titanium disulfide, for example, where we would like to time the collapse of a Mott insulating state, the spacing between the associated energy levels is ~1 eV. Therefore, we plan to probe this system with approximately 1 fs resolution such that distinct energy levels can be resolved while the fastest dynamics can still be captured.

In the future, we expect that extreme timescale spectroscopy will make use of large-scale FEL sources reaching well beyond our original work and capability with tabletop laser-based sources. However, to perform time-resolved experiments, the relative timing of the FEL X-ray pulses must be characterized or controlled on the sub-fs level. Furthermore, for few-fs or even attosecond FEL pulses, the precise temporal profile of each X-ray pulse, which is expected to be highly structured and vary randomly from shot to shot, must be determined to calculate the intensity of the X-ray pulses used in our measurements.

Currently, we are leading an international collaboration to characterize X-ray pulses at LCLS (approved proposal 2011). We expect to continue these efforts at FLASH and the European XFEL. Additionally, we have plans to slice the FEL pulse at FLASH by modulating the energy of the driving electron bunch with a single-cycle optical pulse, which would result in a synchronized and shaped - or controlled - attosecond FEL pulse.



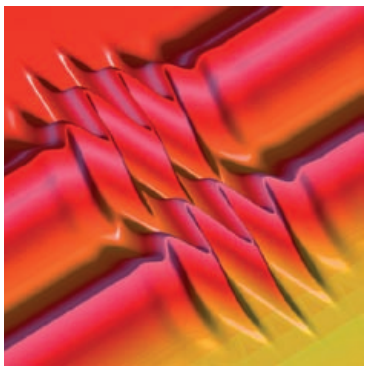
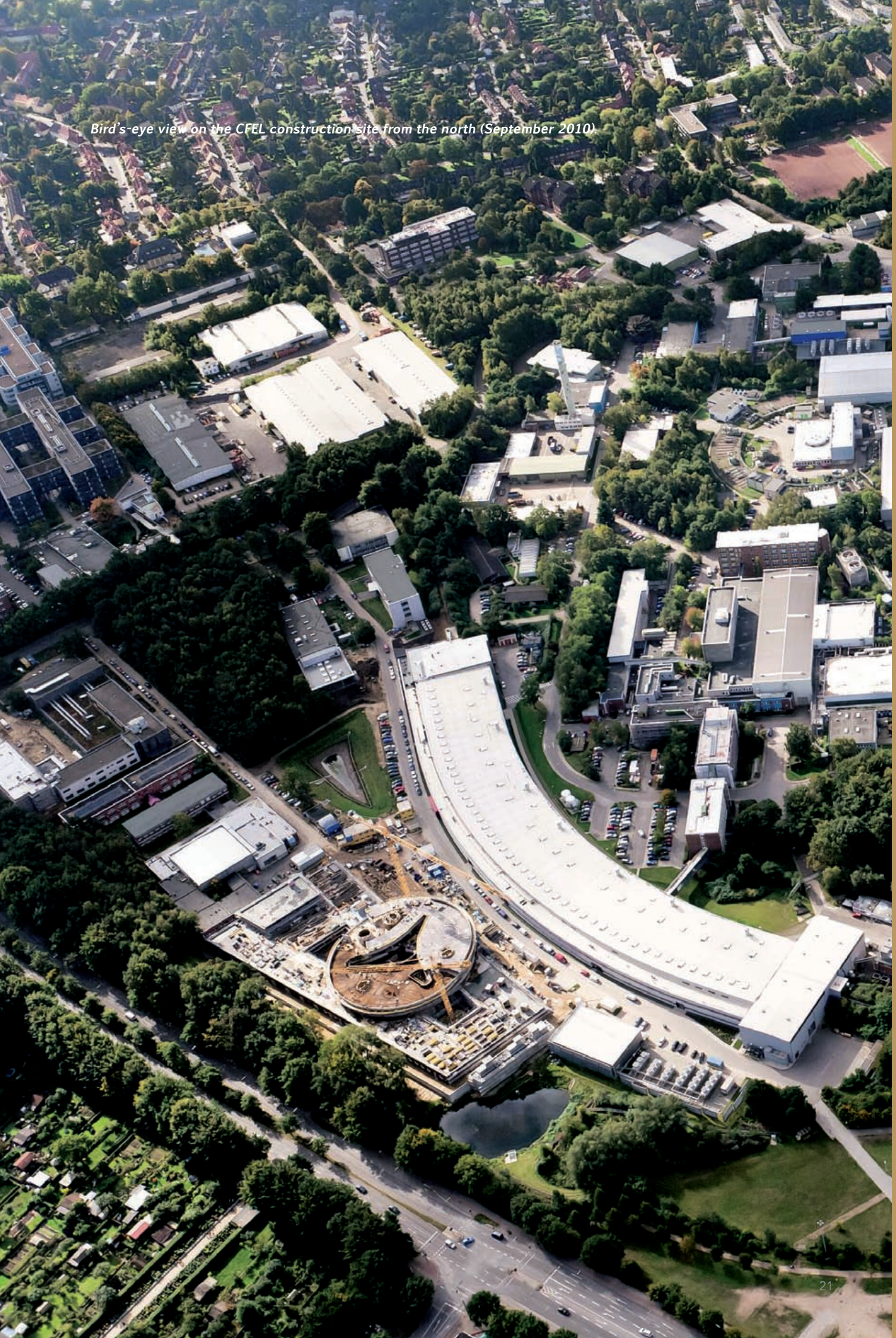


Figure 1: Extreme Timescale Group in the laboratory. From left to right: I. Grguras, H. Höppner, A. Cavaleri, A. Simoncig, S. Huber (left). An illustration of attosecond time-resolved photoemission from core-level and valence-band states in tungsten (right).



Bird's-eye view on the CFEL construction site from the north (September 2010)

ATOMICALLY RESOLVED DYNAMICS DIVISION

DIVISION LEADER PROF. DR. R. J. DWAYNE MILLER

Prof. Dr. R. J. D. Miller

Structural information is essential to understanding chemical and biological processes. However, structures alone are insufficient. The world is dynamic. The very act of chemistry involves an interconversion between atomic positions that lead the system to new molecular species. In this context, biology is powered by chemical processes albeit at highly optimized active sites to direct the chemical process through control over barrier heights and strong correlations in fluctuations imposed by structural constraints. To completely understand molecular processes we need information on structures, dynamics of both electronic and nuclear degrees of freedom, and the energetics driving the process. To this end, the Miller group has developed a number of different spectroscopic tools that enable dissection of the problem towards these three system variables.

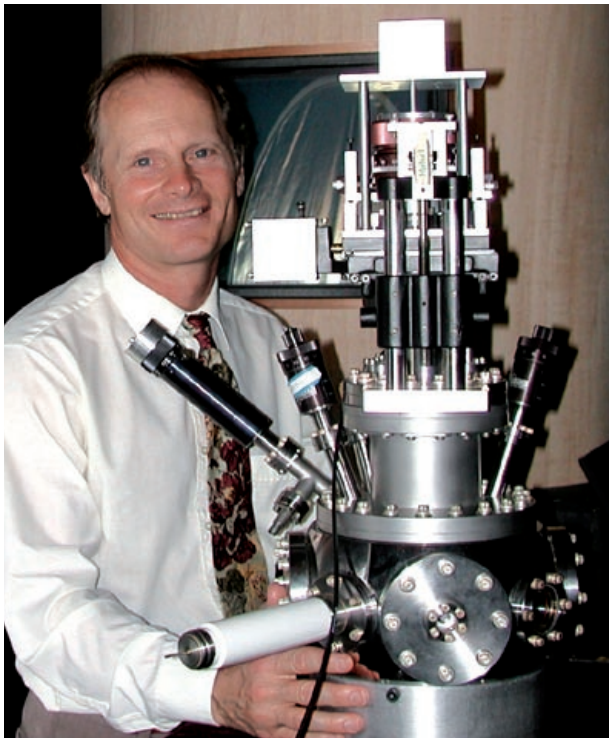


Figure 1: R. J. Dwayne Miller with his "baby" – the 3rd generation electron gun that broke the barrier to resolving structural dynamics on the femtosecond time scale.

Atomically Resolved Dynamics. One of the great dream experiments in science is to watch atomic motions as they occur. Such vision requires extremely high spatial resolution with subpicosecond time resolution. This experiment was first realized by the Miller group with high brightness, nonrelativistic, electron pulses to light up the atomic motions [*Science* **302** (2003) 1382]. It is now possible to directly watch atomic motions at critical points for even complex systems, i.e. observe the passage through the so-called transition state region of polyatomic molecules, the free energy surface of which is a highly multidimensional surface. The concept of a transition state has been a central unifying concept for chemistry and biology and is now open to direct inspection. This experiment has been referred to as "making the molecular movie" and given the extremely high spatial and temporal resolution that has been previously discussed in the context of a gedanken experiment. Recent advances in electron source technology have made it possible to generate 100 femtosecond electron pulses with sufficient number density to execute single shot structure determinations. Further, previously thought intractable problems of determining t=0 (to effectively synchronize the filming process) and fully characterizing electron pulses on the femtosecond time scale have now been solved through the use of the laser pondermotive potential to provide a time dependent scattering source. Synchronization of electron probe and laser excitation pulses is now possible with an accuracy of 10 femtoseconds to follow even the fastest nuclear motions.

Since joining CFEL, the Atomically Resolved Dynamics Group has further increased the bunch charge and has an ongoing collaboration with the Machine Physics Group of DESY, headed up by Klaus Flöttmann, to build a relativistic electron gun to effectively open up all samples to atomic level inspection. Atomic level views of the simplest possible structural transition, melting, have been obtained for a number of systems involving both thermal and purely electronically driven atomic displacements. Optical manipulation of charge distributions and effects on interatomic forces/bonding can be directly observed. New phenomena involving cooperative phase transitions in strongly correlated electron systems have also been observed. The primitive origins of molecular cooperativity have also been discovered.

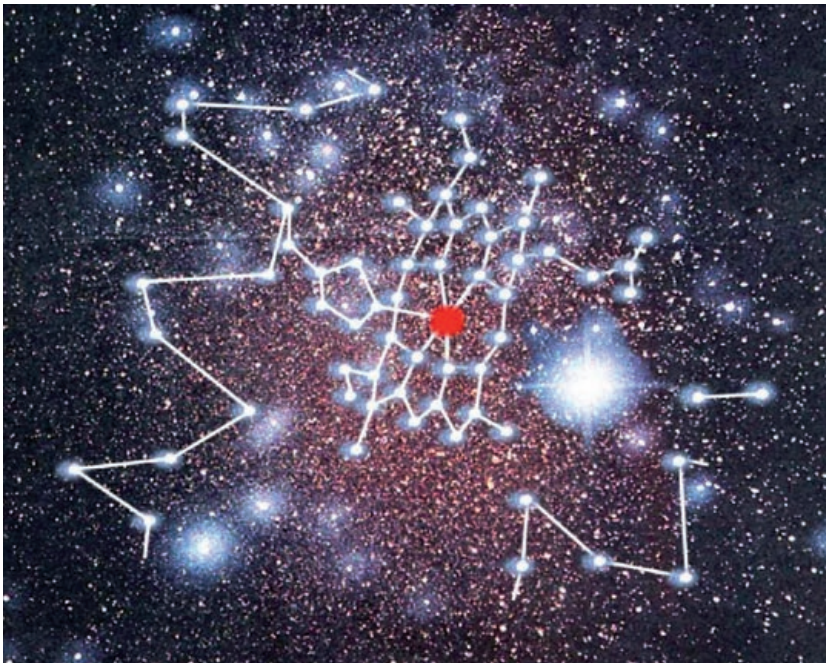


Figure 2: A depiction of the dream experiment driving the research – a direct observation of the transition state in chemistry and biology. Specifically, this figure depicts the heavy atoms at a protein binding site as star like objects moving in response to the release of chemical energy during bond breaking events.

The long range goal of this program is to directly observe the structure-function correlation in biomolecules – the fundamental molecular basis of biological systems. With the new Relativistic Electron Gun for Atomic Exploration (REGAE) coming on line at CFEL/DESY, and recent developments at 4th generation light sources such as the LCLS and soon European XFEL, this goal is now in reach. The challenge is to make the connections of the observed dynamics to topological features of protein structure.

Quantum State Dynamics – the Electronic Coordinate. This aspect of the group's research is headed up by Valentyn Prokhorenko. A new fully general, multidimensional coherent spectroscopy set up has been developed based on recently discovered means to cancel phase noise in interferometer designs. The system is capable of few femtosecond time resolution, and able to generate nearly arbitrary pulse shapes from wavelengths spanning the UV to IR. This system is unique. It is now possible to do many of the experiments used in NMR with respect to coherence transfer between nuclear spins to obtain structures; whereas in the optical domain this system makes it possible to control electronic and nuclear coherences and thereby control chemistry. A new class of experiments is in progress that will make it possible to control energy flow in molecules, enhance quantum interference effects or turn them off, and give direct information on the coupling between a quantum system and the surrounding bath using weak field coherent control concepts developed by the group.

In the past two years, this group has developed coherent control 2D electronic spectroscopy and shown that it is possible to control quantum decoherence even in highly dissipative media such as solution phase dynamics. In addition, by using 2D electronic spectroscopy, it was possible for the first time to map the wavepacket evolution through a conical intersection for the classic photoisomerization of bacteriorhodopsin that also serves as a model system for the primary step of vision. This work showed strong correlations through the conical interface and strong mixing of the two electronic surfaces that is intriguing and now challenges our present understanding of what is considered one of the best defined reaction coordinates.

Energetics – the Driving Force for Chemical and Biological Processes. The group developed picosecond thermal phase grating methods to achieve picosecond time resolution to directly measure energetics on sufficiently short time scales to capture structural intermediates. The reaction energetics and dynamics for heme proteins have been well characterized, as part of the effort to make the structure-function correlation.

Future Prospectus: The new facilities at CFEL have capabilities for programmable pulse shapes from the UV to IR to enable modifying the energetics driving reaction dynamics on the fly. This part of the research program will implement coherent control protocols along with atomically resolved dynamics using the new electron sources for structural probes to directly watch wave function interference effects – to see matter waves in action.

CFEL THEORY DIVISION

DIVISION LEADER PROF. DR. ROBIN SANTRA

Prof. Dr. R. Santra

Theory plays a critical role in modern science. With the help of theory, scientific tools such as free-electron lasers can be put to use more efficiently, i.e., searches for scientific opportunities can be greatly accelerated. Theory often predicts new, previously unobserved phenomena, which inspire the planning and execution of experimental investigations. Moreover, without support by theory the outcome of an experiment lacks a conceptual foundation. It is through theory that we understand nature. The general strategy in theory proceeds in two steps. In the first step, a mathematical model is developed to describe the physical situation under consideration. This mathematical model rests either on fundamental natural laws already established, or on approximations to these laws, or on entirely new theoretical concepts. In the second step, mathematical tools are identified that allow one to find a solution to the mathematical model. In rare cases, it is possible to find a so-called analytic solution, i.e., an explicit equation that represents the solution. In most practical cases, however, the mathematical model can only be solved using numerical techniques. For this reason, theorists make heavy use of computers.

In the CFEL Theory Division, we develop theoretical and computational tools to predict the behavior of matter exposed to intense electromagnetic radiation. Examples for intense electromagnetic radiation include the visible light emitted by modern table-top lasers and the X-rays produced by the latest generation of free-electron lasers. We employ quantum-mechanical and classical techniques to study ultrafast processes that take place on the characteristic time scales on which atoms, and the electrons within atoms, move. The CFEL Theory Division consists of three subgroups: (a) Ab Initio X-ray Physics, (b) Chemical Dynamics, and (c) Modeling of Complex Systems. The subgroup working in the area of Ab Initio X-ray Physics, led by Prof. Dr. Robin Santra, focuses on the microscopic, quantum-mechanical characterization of the interaction of X-rays with atoms and molecules. “Ab Initio” means that the theoretical description employed is based on first principles, i.e., fundamental natural laws. The information obtained in our research is important for maximizing the utility of novel radiation sources such as X-ray free-electron lasers. Of central interest to us is the exploration of novel techniques made possible by the extremely short pulse duration, and the extremely high intensity, offered by X-ray free-electron lasers. We are exploring, for instance, whether such pulses can be employed to directly watch the behavior of molecules in strong optical laser fields. A goal of this research is to find out whether it is generally possible to use strong optical lasers as catalysts of chemical reactions. We are also exploring opportunities for directly observing and manipulating the motion of electrons in matter. Since electrons provide the glue that binds atoms together to form molecules, the ability to control electrons in matter could have revolutionary consequences for applications.

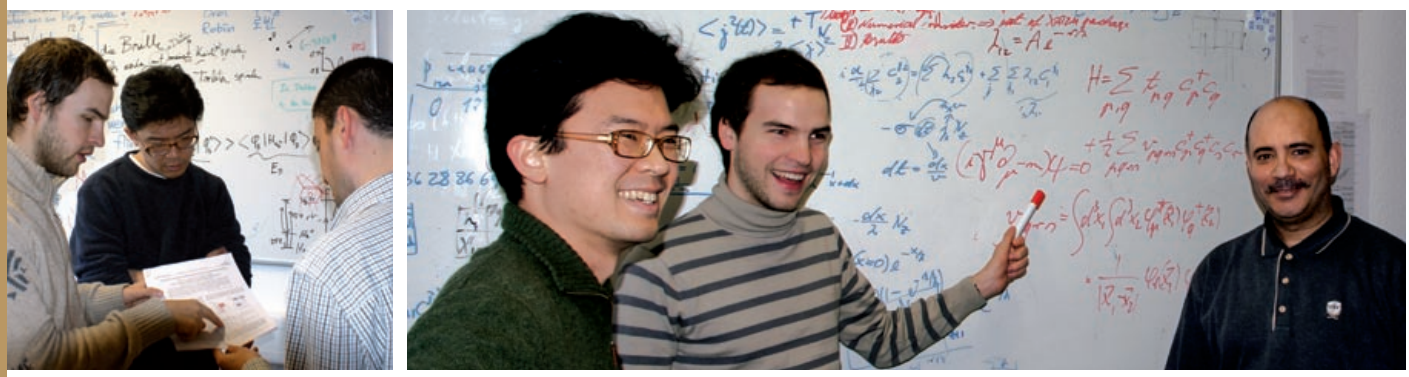


Figure 1: Paper discussion by S. Pabst, S.-K. Son and O. Vendrell (left). Discussion on theories for the interaction of X-rays with atoms and molecules by S.-K. Son, S. Pabst and M. E. A. Madjet (right).

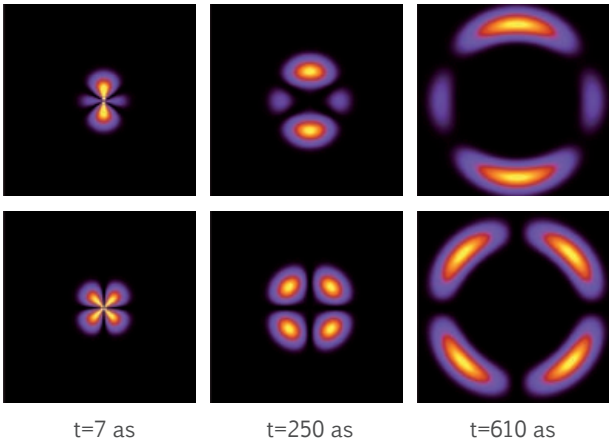


Figure 2: Quantum-mechanical calculations reveal the behavior of an electron ejected from a neon atom by an extreme ultraviolet pulse that is only 100 attoseconds long (1 attosecond = 1 as = 10^{-18} s). Results are shown for three different times after the peak of the attosecond pulse. Panels a) and b) correspond to electron ejection from two different orbitals of neon.

Dr. O. Vendrell

Using an X-ray source, the positions of atoms in matter may be imaged. X-ray free-electron lasers, in particular, produce extremely intense radiation bursts that are so short that they are over before atoms have time to move. X-ray free-electron laser pulses can therefore be used to view chemical reactions as they occur, both in time and space. In this context, the Chemical Dynamics subgroup, led by Dr. Oriol Vendrell, addresses fundamental questions related to the interaction of molecules and clusters with light, and to the application of modern photon sources to studying the dynamics of chemical processes with high spatial and temporal resolutions. This includes deciphering and also predicting the response of matter to the interaction with laser pulses, and proposing new operation modes and techniques that optimize the possibilities of such photon sources. On the other hand, the high intensity and energy of X-ray free-electron lasers are also a main source of damage to molecular systems, inducing changes to the electronic cloud that keeps the atoms together, and consequently to the molecular structure. Radiation damage also occurs in nature when molecules, proteins, etc. are hit by X-rays or other ionizing radiation. Describing and understanding the radiation damage process in a consistent fashion is an extremely challenging theoretical and numerical problem for which dedicated simulation tools are being developed in our group. Research in this area may lead to new ways to alleviate the impact of radiation damage.

Dr. habil. B. Ziaja-Motyka

The Modeling of Complex Systems subgroup, led by Dr. Beata Ziaja-Motyka, explores how the unique properties of X-ray free-electron laser radiation may be employed to characterize and modify extended atomic or molecular assemblies. Among our research interests are: (i) radiation-induced changes in complex systems, (ii) diffraction imaging techniques, and (iii) properties of laser-created plasmas. (Plasmas, often referred to as the fourth state of matter, consist of electrons and charged atomic particles.) The X-ray flashes from a free-electron laser will enable novel 3D insight into the nanoworld and thus shed light on future technological applications. The theoretical goal is to investigate ultrafast transformations in solids induced by intense radiation, such as changes of optical and magnetic properties of materials, and formation of defects. Also, using the X-ray flashes from a free-electron laser, scientists can uncover the atomic structure of biomolecules, cell constituents, and viruses. This provides the basis for future medical breakthroughs. Research by the theory group is focused on novel techniques to retrieve static and dynamic information on the structure of the imaged objects at atomic resolution. Finally, with an X-ray free-electron laser, plasmas can be created that are as hot as the interiors of giant planets. It will be possible to follow the evolution of dense plasmas in time. The theoretical research of our group concentrates on the properties of plasmas far from equilibrium, and on the high-field regime that leads to the creation of new states of matter.

ULTRAFAST OPTICS AND X-RAYS DIVISION

DIVISION LEADER PROF. DR. FRANZ X. KÄRTNER

Prof. Dr. F. X. Kärtner

X-ray FEL facilities are combined accelerator and laser laboratories. Ultrashort pulse lasers are essential in producing electron beams with unprecedented brightness, in precise control of microwaves for acceleration and bunch compression and electron beam diagnostic. They provide ultrashort visible, infrared and terahertz (THz) pulses. These pulses may be as short as a single-cycle and are used for time resolved experiments or in advanced FEL schemes for electron beam modification. Ultralow noise femtosecond lasers enable distribution and synchronization of all microwave and optical sources in these often many km-sized facilities with femtosecond and potentially attosecond precision.

The Ultrafast Optics and X-ray Division develops novel ultrashort pulse lasers and laser based instrumentation to achieve:

- advanced control, monitoring and seeding of X-ray FELs,
- stand-alone compact soft and hard X-ray sources to study physical processes on the attosecond time and Ångström to nanometer length scale.

Attosecond Precision Photonics is based on ultralow timing jitter optical pulse trains from mode-locked lasers. The high timing precision of these pulse trains enables applications such as (i) femto- and attosecond level timing distribution and synchronization as well as (ii) high speed sampling and down-conversion with photonic Analog-to-Digital Converters (ADCs). As an example, Figure 1 shows part of a fiber optic timing distribution and synchronization system for X-ray FELs. Tightly synchronized optical pulses are delivered to all positions in a FEL facility where precise timing information is needed. The input optical pulse is split into a reference pulse (pulse 1) and a pulse transmitted through the fiber link. At the fiber end, part of the transmitted pulse is coupled out as the stabilized timing signal, and the rest of the pulse is reflected back by a Faraday rotating mirror having an orthogonal polarization state (pulse 2). Pulse 1, the reference pulse, and pulse 2, back-reflected from the link, are combined at the input of a single-crystal balanced cross-correlator, detecting the timing offset between the two pulses, Δt. The output from the balanced cross-correlator drives the PZT and the collimator-mounted motorized translation stage to compensate the fast and slow noise introduced to the link by temperature and environmental perturbations, respectively. With the help of industrial partners a multi-link system based on this concept was installed at the VUV FEL FERMI at ELETTRA, Sincrotrone Trieste, Italy in 2010. Another application of this technology are high sampling rate and high resolution photonic ADCs. Current electronic ADCs are limited in sampling of rf-signals with high resolution by electronic jitter. Today, this jitter is about 100 fs, enabling sampling at 1 GSa/sec with 10 effective bits. Photonic ADCs powered by femtosecond lasers enable reduction of this jitter by three orders of magnitude and beyond. This gives hope to potentially sample 50 GHz signals at 100 GSa/sec with up to 14 effective bits.

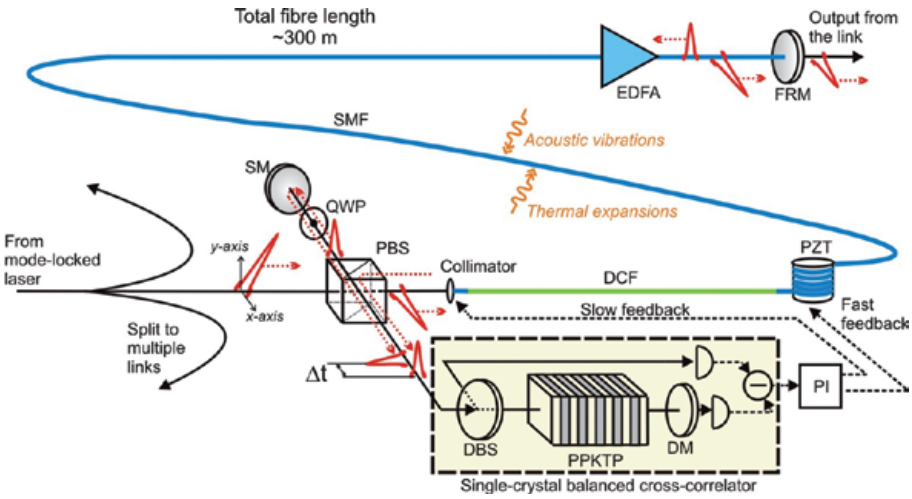


Figure 1: Timing-stabilized fiber link. Schematic of the timing-stabilized fibre link (SM, silver mirror; QWP, quarter-wave plate; PBS, polarizing beamsplitter; DBS, dichroic beamsplitter; DM, dichroic mirror; PPKTP, periodically poled KTai-OPO4; PD, photodiode; DCF, dispersion-compensating fibre; PZT, piezoelectric transducer; PI, proportional-integral controller; SMF, single-mode fibre; EDFA, erbium-doped fibre amplifier; FRM, Faraday rotating mirror) [J. Kim et al., Nat. Photon. 2 (2008) 733].

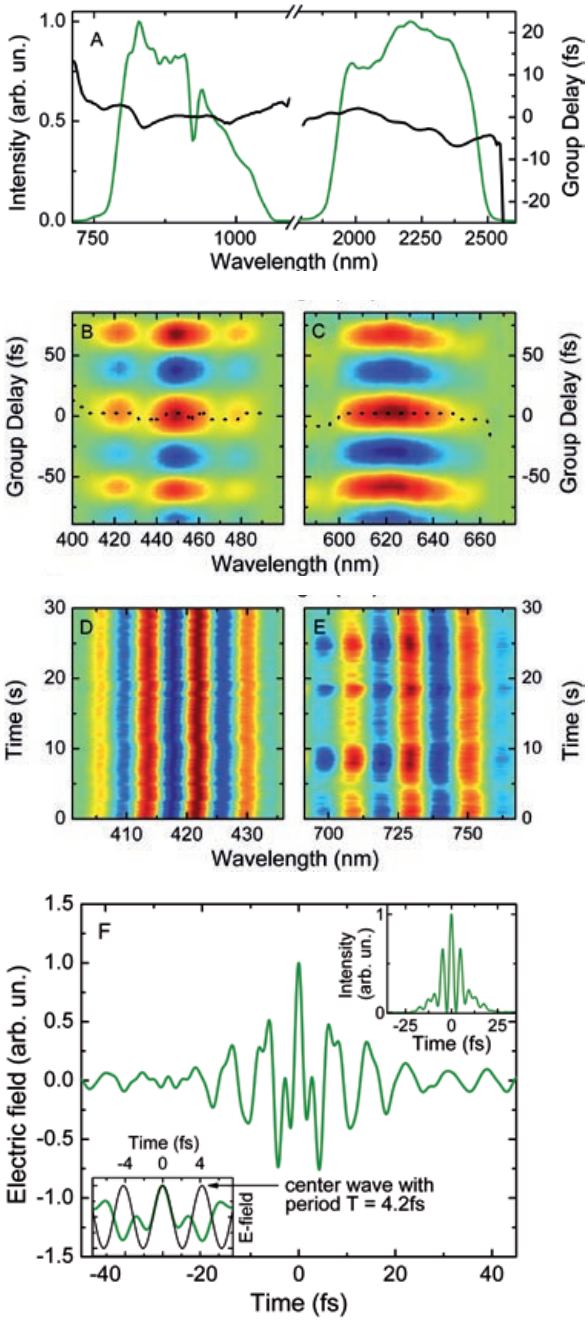


Figure 2: (A) Spectra of combined 800-nm and 2-micron OPCPA pulses, indicating power spectral density, and group delay, extracted from the measured two-dimensional spectral interferometry traces shown in (B) and (C). (D) 1f-2f and (E) 1f-3f interferograms indicating 130-mrad and 150-mrad CEP fluctuations for 800-nm and 2-micron OPCPA systems, respectively. (F) synthesized sub-cycle waveform with intensity shown on upper right inset and fit to the carrier wave, lower left inset.

High Harmonic Generation is used to achieve laser driven ultrafast tabletop coherent radiation sources in the extreme ultraviolet (XUV) (120 – 10 nm) and soft X-ray (10 – 0.1 nm) range. These sources enable seeding of X-ray FELs, time-resolved investigation of ionization processes, imaging of molecular orbitals and soft X-ray lensless imaging. They are based on high intensity ultrafast laser pulses that are focused into noble gases to produce high-order harmonics of the laser frequency by a non-perturbative nonlinear optical process, termed High Harmonic Generation (HHG). HHG involves laser-induced electron ionization, acceleration and recombination. All these processes depend critically on laser parameters such as frequency and intensity, and material properties such as ionization threshold, dipole transition probabilities, and linear refraction of the gas.

The development of these sources critically depends on robust, high power, and optimized laser sources, as well as a sophisticated understanding of parameters affecting HHG efficiency. Our research program combines these two aspects. For example, we are developing ultrabroadband optical parametric chirped pulse amplifiers (OPCPAs) at near- and mid-infrared wavelengths that are groundbreaking both in pulse duration and average power. In pursuit of these aims, we synthesized high-energy sub-cycle optical pulses by locking the output of 800-nm and 2-micron wavelength OPCPAs both in phase and in timing coherently together. The OPCPAs are seeded from a common octave spanning, carrier-envelope phase controlled, 5-fs Ti:sapphire laser. The combined spectrum spans 1.5 octaves, and has the capability of producing 2.5-fs, 0.6-cycle pulses, a pulse width ideal for efficiently generating isolated attosecond pulses through HHG for applications in **Attosecond Science,** see Figure 2. Average power scaling of this synthesizer is pursued based on cryogenically cooled Yb:YAG amplifiers jointly developed with MIT Lincoln Laboratory. We are investigating the scaling of HHG efficiency through experiments, analytic theory, and numerical simulations.

Ultrafast Laser Technology is key to all our research efforts. We are developing broadly few-cycle carrier-envelope phase controlled oscillators, femtosecond fiber and waveguide lasers, femtosecond enhancement cavities, novel dispersion compensating mirrors, high energy fiber and solid-state amplifiers. These technologies support fundamental studies and a wide range of laser applications.

MAX PLANCK ADVANCED STUDY GROUP

DIVISION LEADER PROF. DR. JOACHIM ULLRICH

FINITE QUANTUM SYSTEMS, COHERENT IMAGING & FOREFRONT INSTRUMENTATION.

Prof. Dr. J. Ullrich

Free-Electron Lasers (FEL) deliver light flashes with unprecedented properties: the pulses are many billion times more intense and more than a thousand times shorter than those from conventional sources. Their wavelengths are so short that objects on the nanometer and even Ångstrom scale, e.g. the atoms in a molecule, can be observed with a time-resolution of a few femtoseconds (1 fs = 10^{-15} s). Thus, FELs are the fastest ever, ultrahigh-resolution snapshot cameras! The Max Planck Advanced Study Group (MPG-ASG) at CFEL pursues forefront science exploring questions like:

- How do these extremely intense, ultra-short light pulses interact with the building blocks of matter, atoms and molecules? Can we simulate the extreme conditions close to the light-escape horizon of a black hole? Can we unravel the chemistry in upper planetary atmospheres or in interstellar clouds where complex organic molecules, potential precursors of life, have been found? Will we be able to "record a molecular movie", i.e. trace the motion of individual atoms or of binding electrons during chemical reactions in time?
- How do the light pulses interact with more complex systems, conglomerates of several thousands to millions of atoms like clusters or aerosols? Can we follow vibrations in solids, the chemistry in solutions or in an environment in time? Will we be able to "image" biomolecules, aerosols, nanocrystals, viruses or bacteria at atomic resolution and thus get a glimpse of how they function before they evaporate in the light-flash?
- And last but not least, what kind of new instrumentation do we need in order to answer these questions and to fully exploit the unprecedented FEL pulse characteristics?

Reflecting the interdisciplinary challenge posed by the new light machines, the MPG-ASG is a novel, highly flexible division established within CFEL which is open to and supportive of any group in any Max Planck Institute (MPI) that is interested in science with FELs. This MPG-ASG – a "virtual MP department" – is headed by Prof. Dr. J. Ullrich, a physicist, and Prof. Dr. I. Schlichting, a biologist.

Presently, eight MPIs from both the Biological-Medical (BMS) and the Chemical-Physical and Technical Sections (CPTS) of the Max Planck Society (MPG) collaborate within and are supported by the MPG-ASG. Currently they are assisted by a central expert group of six scientists, four students and two technicians located at the CFEL in Hamburg. The "MPG-ASG Hamburg", whose members are shown in Figure 1, is complemented by two newly established independent research groups: one in chemistry, lead by Melanie Schnell, and one in theory, lead by Nina Rohringer.

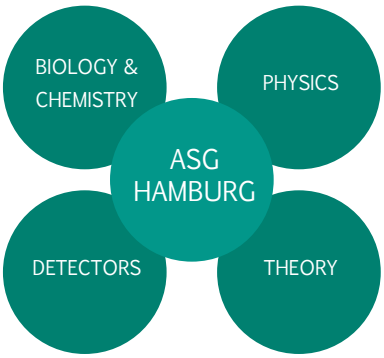


Figure 1: The MPG-ASG Hamburg, located at CFEL, forms the heart of the ASG. It ties together and supports activities of the participating Max Planck institutes that combine expertise in biology, physics, chemistry and theory, reminiscent of a clover leaf (right). Left to right: S. Epp, D. Rolles, C. Schmidt, A. Rudenko, B. Erk, F. Krasniqi, B. Rudek, L. Foucar, A. Hömke, M. Schnell, Y.-P. Zong, J. Ullrich (left).

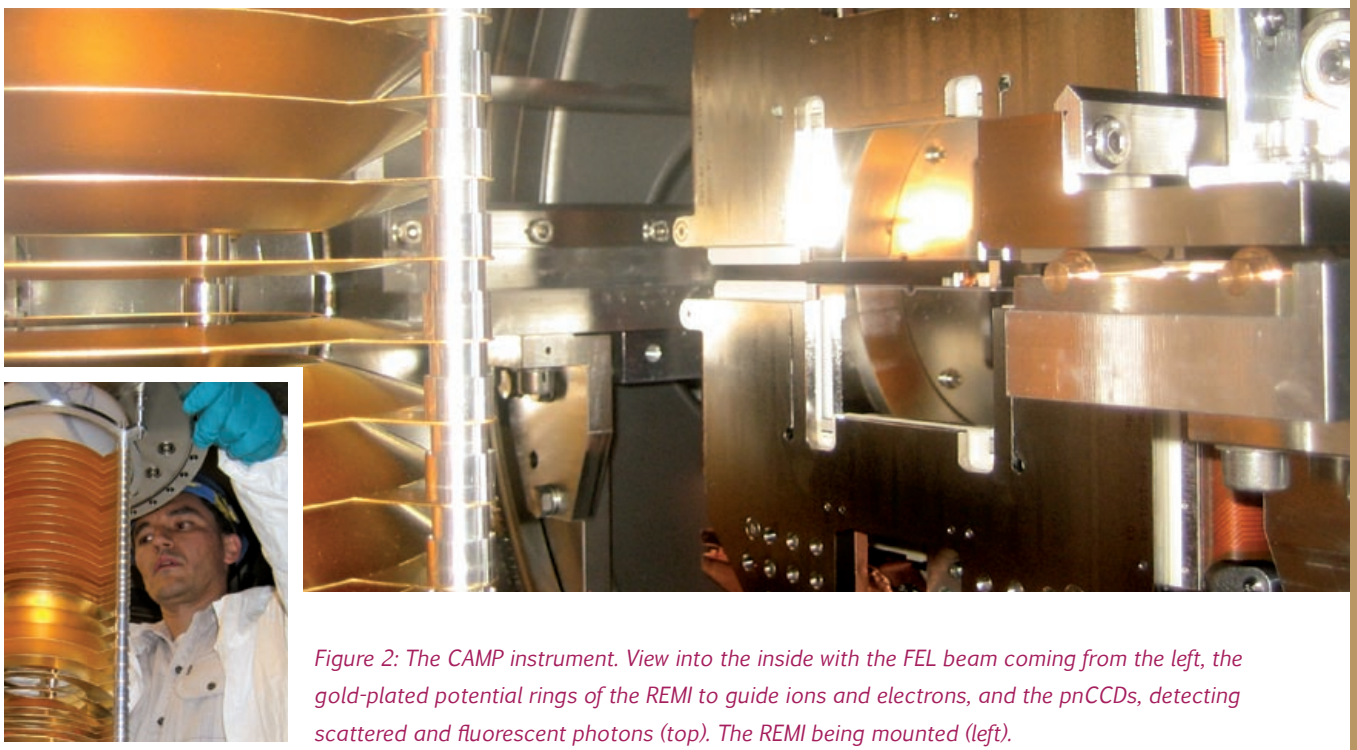


Figure 2: The CAMP instrument. View into the inside with the FEL beam coming from the left, the gold-plated potential rings of the REMI to guide ions and electrons, and the pnCCDs, detecting scattered and fluorescent photons (top). The REMI being mounted (left).

Central to the MPG-ASG mission is advancing FEL-enabled science by:

- efficiently supporting forefront research projects of individual MPIs,
- fostering collaborations across disciplines within the MPG and beyond,
- designing and developing advanced instrumentation.

One show case example for simultaneously achieving all three goals is the design, realization, and successful operation of the **C**FEL-**A**SG **M**ulti-**P**urpose (**CAMP**) instrument. Driven by the interdisciplinary scientific visions of the ASG, and enabled by ASG's unique, division-like, effective organizational structure, this apparatus was created within less than two years in collaboration between ASG physicists, biologists, chemists, detector scientists and theoreticians in consultation with the scientific community, ultimately setting new standards in FEL research and instrumentation which reach far beyond the ASG.

CAMP (Figure 2) enables the simultaneous detection of all fragments that form upon interaction of an FEL pulse with matter. This well-established technology, known as a "reaction microscope" (REMI), has been combined for the first time with special CCD chips to record the scattered FEL light. The chips, fabricated by ASG, are the world's largest, low-noise and fast-read-out X-ray cameras allowing to unravel the structure of FEL-illuminated objects. Although the objects are ultimately destroyed by the FEL pulse, their fragments tell us about the fate of the sample and the details of its evaporation-like destruction.

Indeed, first experiments indicate that the FEL "shutter time" is short enough to "beat the heat": By taking millions of pictures, ASG scientists, their partners in CFEL, and collaborators could catch a glimpse of aligned molecules, of nanoscaled clusters and aerosol particles, of nanocrystals, viruses and plasmas.

Since 2007, the MPG-ASG has been at the cutting edge of FEL science. Four international workshops were organized, attracting leading scientists worldwide from all institutions active in FEL research. MPG-ASG groups have been leading scientists in about one third of all proposals at FLASH. More than 30% of all experiments in the first year of operation of the world's first X-ray laser, the LCLS at Stanford, took place in CAMP, actively involving MPG-ASG scientists. Moreover, they have substantially contributed to pioneering measurements at Japan's SCSS test facility. MPG-ASG scientists are essential members of an envisioned "Max Planck Center at Stanford". They play a key role in an approved $ 13 Mio project between MPG, LCLS and DOE for developing 2nd generation instrumentation at LCLS (LAMP), as well as in a BMBF-supported project with German universities on imaging instrumentation at FLASH. The MPG Semiconductor Laboratory as part of ASG has invented one of the three successful X-ray detection concepts with ultra-fast readout for the European XFEL, based on Active Pixel Detectors (DePFETs).

UNIVERSITY OF HAMBURG ADVANCED STUDY GROUP

DIVISION LEADER PROF. DR. WILFRIED WURTH

FUNDAMENTAL LIGHT-MATTER INTERACTION, ULTRAFAST SCIENCE, ACCELERATOR-BASED LIGHT SOURCES.

Prof. Dr. W. Wurth

Free-electron laser sources like FLASH, the free-electron laser at DESY in Hamburg, or the Linac Coherent Light Source (LCLS) in Stanford with their unprecedented brilliance, their ultrashort pulses and their coherence properties are fantastic sources for extreme ultraviolet, as well as soft and hard X-ray radiation. As microscopes with unique spatial- and temporal resolution they open up completely new areas of research. The Advanced Study Group of the University of Hamburg focuses the very strong activities in FEL science which existed at the University of Hamburg already prior to the foundation of CFEL. Currently driven by groups of the Physics Department the ASG is envisioned to act as a nucleus for interdisciplinary FEL science at the University. Within the UHH-ASG new junior research groups are and will be established which shall provide excellent opportunities for young scientists in FEL science. The main scientific areas which are currently pursued by members of the UHH-ASG are:

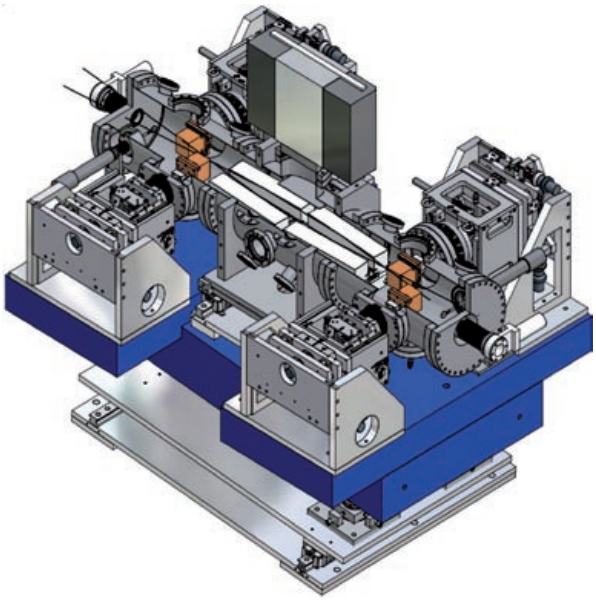


Figure 1: XUV beamsplitter designed, constructed and built by members of the UHH-ASG.

Investigation of fundamental light-matter interaction

Free-electron lasers with their capability to produce extremely intense short wavelength radiation allow for the first time to study the simultaneous or quasi-simultaneous interaction of more than one XUV- or X-ray photon with an atom, a molecule or a solid. The nonlinear interaction of photons with the electrons in a quantum system is well known and very important when optical lasers interact with matter. With the new FEL sources such processes are accessible in the XUV- and X-ray regime. Their understanding is of fundamental importance for FEL applications such as coherent imaging of biomolecules and nanocrystals and real time movies of chemical reactions and is one of the main research topics in the Advanced Study Group of the University. Especially the imaging of small particles will also greatly benefit from the controlled manipulation of these particles by laser light fields such as “optical tweezers” and optical traps. These manipulation techniques are another research focus of the ASG.

Ultrafast science

Ultrafast processes in molecules, clusters, and at surfaces and interfaces, are of central importance for the understanding of elementary chemical reactions, the evolution of photochemical and biophysical processes, and molecular electronics. In solids they govern the subtle interplay between microscopic excitations that leads to surprising emergent macroscopic properties such as high-temperature superconductivity. The most important relaxation processes occur on femtosecond time scales and if electron dynamics is concerned even in attoseconds. With FELs the investigation of ultrafast processes using stroboscopic techniques on atomic length and time scales is within reach. Therefore, another key research topic of the UHH-ASG is ultrafast dynamics, in particular in the electronic system.

Innovative concepts for accelerator-based light sources and X-ray imaging detection schemes

Free-electron lasers see an extremely rapid development in source properties such as peak brilliance, pulse duration, and spatial and temporal coherence. In particular, the quest for ever shorter pulses with controlled pulse proper-

Figure 2: Members of the UHH-ASG performing surface femtochemistry experiments with the surface science collaboration at the SXR instrument at LCLS in Stanford.

ties has led to numerous new concepts which are currently pursued at the new sources. Especially, the idea to seed the free-electron laser pulse with an extremely well-defined pulse from another laser has triggered a lot of activities world-wide. Members of the ASG of the University are key players in this research area. They develop innovative concepts for seeding of FEL sources and they investigate possibilities to achieve and control very short FEL pulses down to a few femtoseconds and below. Another important parameter for the usage of free-electron lasers in many research areas is the repetition rate at which the pulses are delivered which also governs the available average flux. Here the superconducting accelerator technology which is used at FLASH and will be used at the European XFEL is the key technology for the highest repetition rates. Mandatory for the efficient use of the pulses are developments in detector technology for X-ray imaging. Members of the UHH-ASG are important partners in the detector development program at the European XFEL.

Since its foundation in 2007, the UHH-ASG has contributed very significantly to the development of FEL sources, to highly innovative instrumentation at the new sources and to fore-front science with free-electron lasers. Currently the members of the UHH-ASG come from the Institutes of Experimental Physics, Laser Physics and Applied Physics of the Physics Department within the Faculty of Mathematics, Informatics and Natural Sciences of the University of Hamburg.

Members of the UHH-ASG play a significant role in the BMBF priority program FSP-301 “FLASH: Matter in the light of ultrashort and extremely intense X-ray pulses” (spokesperson: Wilfried Wurth) which provides major parts of the necessary instrumentation at the FLASH facility. An intense collaboration exists with Stanford University and Lawrence Berkeley National Laboratory in the framework of the consortium „Soft X-ray Materials Science“ at the Linac Coherent Light Source (LCLS), the free-electron laser at SLAC National Accelerator Laboratory in Stanford. Furthermore, UHH-ASG members are part of excellence in graduate education through a DFG research training unit on “Physics with new advanced coherent radiation sources” which has just recently been extended for four more years after receiving highest marks in the evaluation. They were among the driving forces of the Landesexzellenzcluster “Frontiers in Quantum Photon Science” within the excellence initiative of the State of Hamburg. The focus of this cluster is on the establishment of young investigator groups at the border line between the Center for Optical Quantum Technologies and CFEL and hence, to foster the synergy between these two research centers on the Photon Science Campus Bahrenfeld. Together with the other partners at CFEL the members of the UHH-ASG are also at the nucleus of a new SFB initiative on “Light induced dynamics and control of correlated quantum systems” and a new proposal which is aimed at the establishment of a Hamburg Center for Ultrafast Imaging as an interdisciplinary research cluster at the University of Hamburg within the Federal excellence initiative.

COHERENT IMAGING DIVISION

The CFEL Coherent Imaging Division pushes X-ray imaging beyond conventional resolution limits caused by radiation damage and technology. We are pursuing "diffraction before destruction" imaging, whereby the ultrafast and ultraintense X-ray pulses give rise to measurable diffraction signals from weakly scattering objects. The dose to the sample may be more than one hundred times the conventional tolerable dose for biological materials. However, this dose is delivered on a timescale shorter than the time for radiation damage to manifest. The inertia of atoms keeps them in place long enough for the single-pulse diffraction pattern to represent the undamaged object. The method is applicable to single non-periodic objects, ensembles of laser-aligned molecules, and nanocrystals of proteins. We have confirmed the validity of this concept to sub-nanometer spatial resolution.

We proposed and demonstrated X-ray FEL nanocrystallography as a method to collect high-quality diffraction data for structure determination, by carrying out the analogous steps to single particle imaging. In December 2009 and June 2010, we carried out the first experiments at LCLS in nanocrystallography and single particle imaging. Experiments were carried out in the CFEL Max Planck ASG CAMP instrument (see page 29), as part of the Imaging Collaboration led by the CFEL Coherent Imaging Group. Millions of single-pulse single-particle diffraction patterns were recorded from nanocrystals of the photosystem I complex, lysozyme, cathepsin, and several others. Strong Bragg diffraction peaks were observed at 7.5 Å resolution, the highest accessible by the detector, with X-ray pulses of 6.2 Å wavelength. The single-pulse dose to the sample exceeded 3 GGy, which is 100 times the dose that proteins can usually tolerate in conventional synchrotron experiments. Our results confirm a plasma physics model that describes the heating and disintegration of the crystal during the pulse [*ACS Nano* 2010 advance online, DOI: 10.1021/nn1020693]. We have used this to predict that atomic resolution will be possible once beamlines at LCLS are available for measurements at shorter wavelength. This method may revolutionize structural biology by sidestepping the requirement to grow large well-diffracting protein crystals. In the case of photosystem I, the high-resolution synchrotron structure required 13 years of effort to produce high quality crystals.

The nanocrystals flow across the X-ray beam in a microjet of water, developed by our collaborators at Arizona State University. The concentration of crystals in the suspension is set so that no more than a single crystal is exposed per pulse. This crystal is in a random orientation, and gives rise to a single crystal "still" diffraction pattern. The full 3D diffraction pattern is built up from many such diffraction patterns, but first each must be oriented with respect to all others to build up tomographic information. Compared with the continuous diffraction patterns from non-crystalline

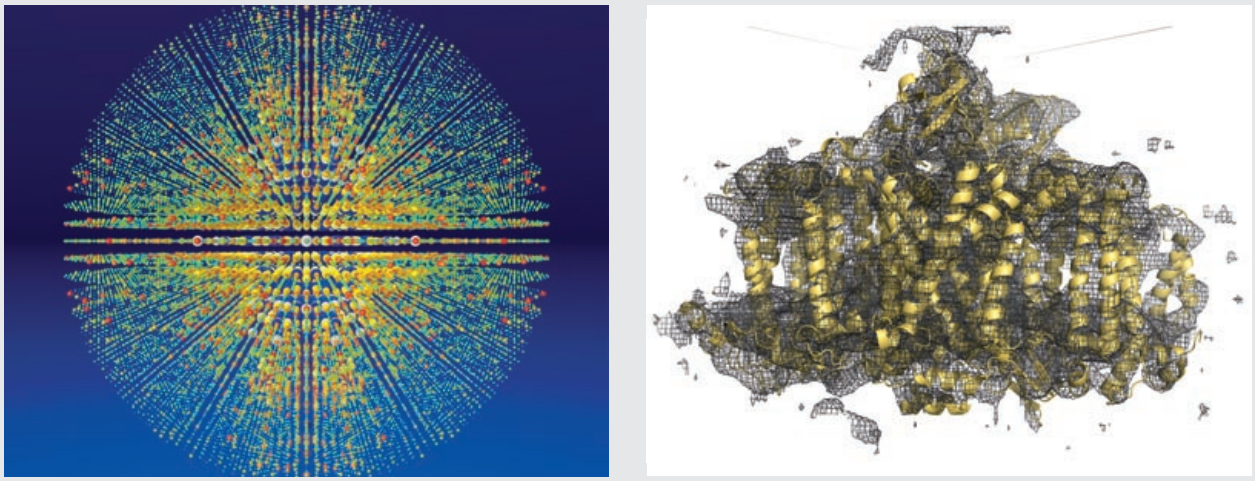


Figure 1: 3D molecular structure factors of the membrane complex photosystem I, merged from over 15 000 indexed nanocrystal patterns recorded at LCLS (left). The structure of PS I refined from the data is shown at right. The crystals were grown by Petra Fromme at Arizona State University.

objects, crystals give a particular advantage that the pattern of Bragg spots very effectively encodes the orientation of the crystal. We have developed a software suite, CrystFEL, to carry out indexing of the millions of diffraction patterns collected and the merging of these into a 3D single crystal pattern. Each structure factor in this pattern is the combination of hundreds of partial reflections from different crystals, and is an integration over these crystal shapes and orientations, just as is carried out in the formation of Debye-Scherrer rings in a powder diffraction pattern. Indeed, our pattern is a 3D powder pattern, collected one grain at a time, where each grain is oriented before integration. These steps are essentially equivalent to those required to build up the 3D single-molecule diffraction pattern, which we are approaching by making smaller and smaller nanocrystals.

From studies of the dependence of the nanocrystal diffraction measurements on the X-ray pulse duration, we have determined that the high-resolution structure persists for about the first 30 fs of the pulse. During this time the periodic order of the unit cells contributes to the diffraction pattern. As the crystal starts to explode, order is initially lost at short length scales, which progresses to longer correlation lengths. The arising disordered structure gives rise to a much weaker diffuse background. The effect of the explosion can be accounted for quite trivially in the measured diffraction data, and the quality of our data can be verified by structure refinement from the merged 3D diffraction data. A refinement of photosystem I shows very good agreement with the known structure of this complex. This is remarkable, given that our data are collected at close to room temperature whereas conventional synchrotron data can only be obtained upon freezing the sample to cryogenic temperatures. The structure has been deposited in the Protein Data Bank, with the ID number 3PCQ. This is the first X-ray FEL structure to be deposited to the PDB.

We have carried out a series of experiments on single particle imaging at FLASH and LCLS, as part of the international Imaging Collaboration. Coherent diffraction patterns are collected from reproducible particles from a beam generated by aerodynamically focusing an aerosol source [*Aerosol Sci. Tech.* **44** (2010) i-vi]. We have collected hundreds of thousands of diffraction patterns from a range of biological and nanoscience particles including single viruses, cells, single spherical and nonspherical nanoparticles and their clusters, and aerosol particles such as soot. The recorded diffraction patterns exhibit high signal to noise and high contrast, which we can readily phase to give high-resolution 2D images. These images indicate the high coherence of the X-ray laser pulses, and show no evidence of sample destruction by the pulses.

We have succeeded in performing the 3D merging of continuous diffraction patterns of ellipsoidal nanoparticles, using an expectation maximization algorithm [*Phys. Rev. Lett.* **104** (2010) 225501]. Every measured diffraction pattern is a randomly-oriented slice of the 3D Fourier transform of the object. Unlike in nanocrystallography, the orientation of the particle is not unambiguously encoded in the diffraction pattern. The algorithm iteratively aligns each pattern in turn to best fit a model constructed from all the patterns, which successively refines the model to reach agreement between

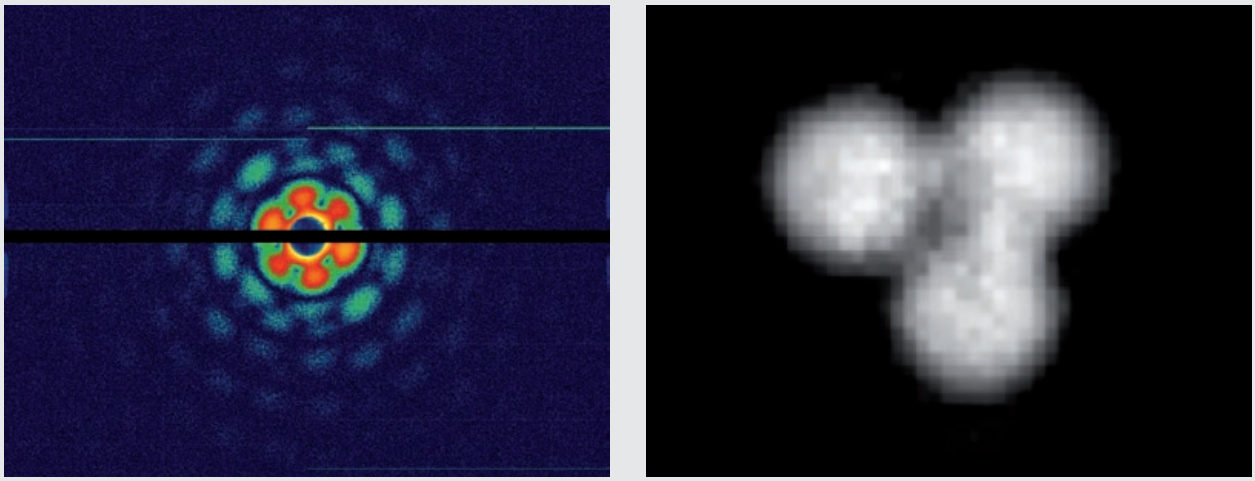


Figure 2: Single-shot coherent diffraction pattern of a cluster of 140-nm diameter latex spheres (left) and the image obtained by phase-retrieval (right). The cluster was captured on the fly at LCLS, with a pulse of 0.69 nm wavelength.

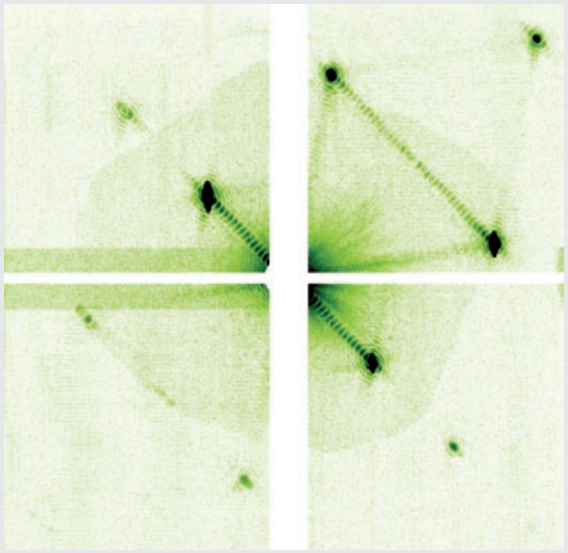


Figure 3: Single-pulse highly-sampled diffraction pattern of a photosystem 1 nanocrystal, recorded at LCLS, showing the low-order Bragg peaks that are modulated by the "shape transform" due to the finite size of the crystal. This coherent diffraction gives the opportunity to obtain much more information about the underlying molecular transform than in conventional crystallography, which may offer a way to phase the diffraction data. This particular crystal had a width of 19 unit cells, as can be determined by the number of interference fringes.

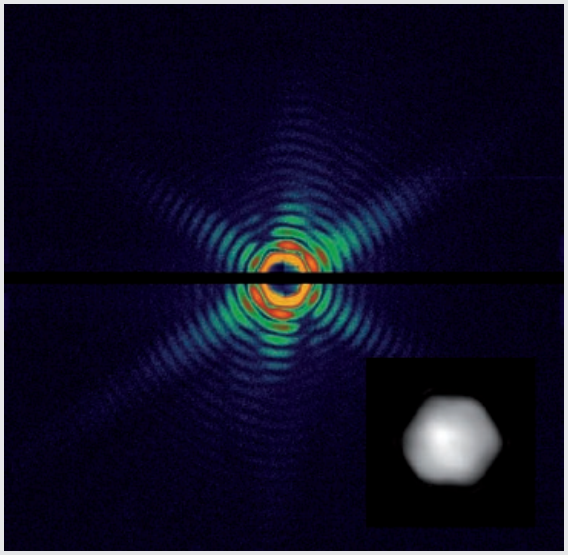


Figure 4: Diffraction pattern of a giant Mimivirus particle, recorded at LCLS, showing diffraction to a resolution of 14 nm. A reconstruction of this single view of the particle is shown in the inset, obtained by an interative phasing algorithm. The virus particles were prepared by Prof. Janos Hajdu and collaborators from Uppsala University.

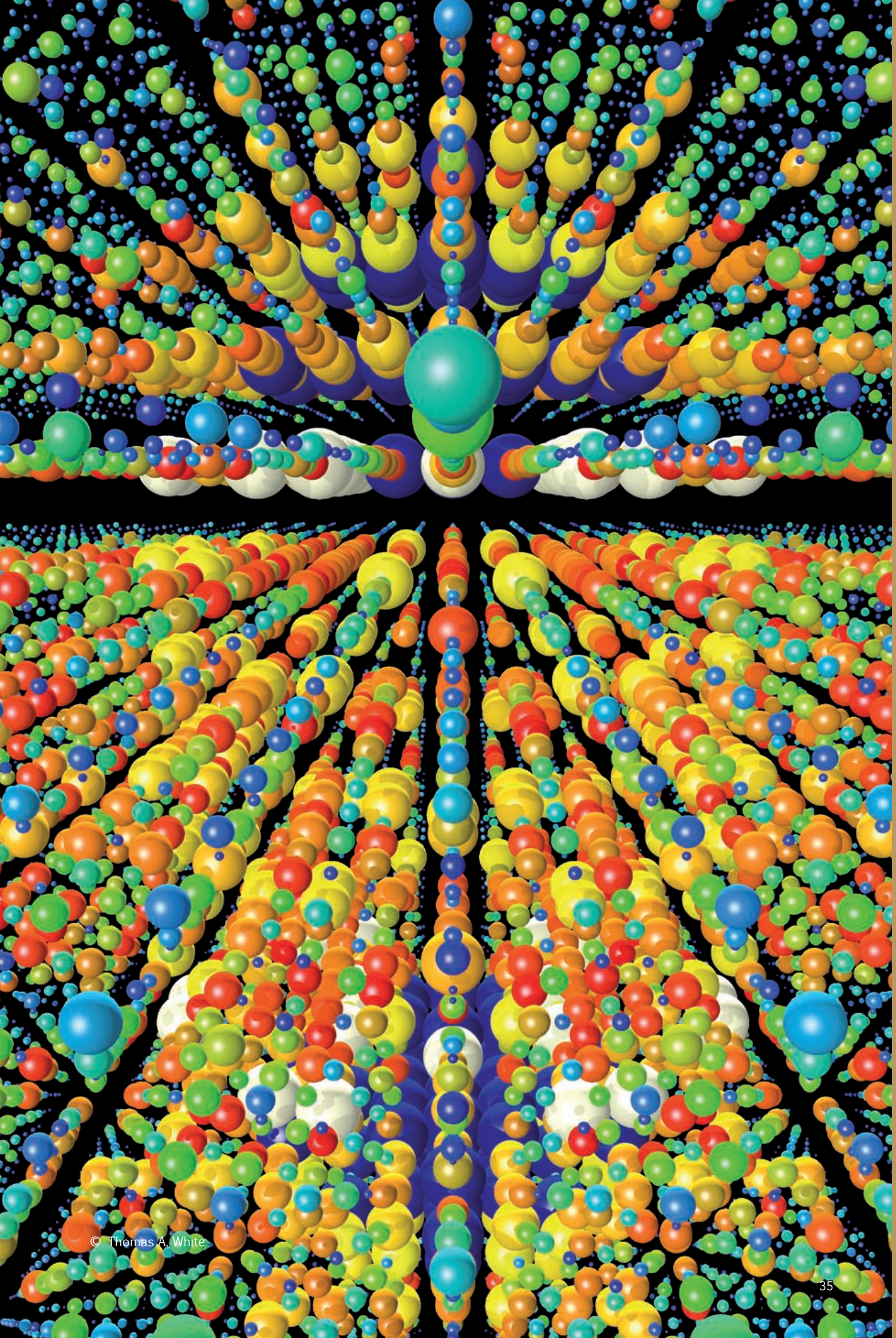
all patterns. This is an important demonstration that shows the feasibility of this approach for single molecule imaging, and we are currently applying the method to more complicated structures such as viruses.

The achievable resolution of non-periodic objects will be limited by the degree of damage during the pulse. We confirmed our earlier predictions that damage can be suppressed by encasing the particle in a sacrificial layer, by carrying out time-delay holographic recordings of the explosion of aluminum nanoparticles encased in a layer of silicon [*Phys. Rev. Lett.* **104** (2010) 06480]. These materials mimic the scattering of protein in water at shorter wavelengths. We measured the effect of the X-ray pulse on the sample, by reflecting that pulse back on to the sample to coherently probe it at a later time. The use of a tamper delayed the explosion of the nanoparticles by ~ 1 ps at a resolution of 13 nm.

In contrast to the "top down" approach of determining macromolecular structure from nanocrystals we are also pursuing a "bottom up" strategy by creating a cold beam of aligned molecules , i. e., 2,5-diiodobenzonitrile and 1,4-dibromobenzene. The molecules are seeded in 50 bar of helium, supersonically expanded into vacuum, separated from the atomic seed gas, and quantum-state selected using an electric deflector. The ensembles are then adiabatically aligned using the strong ac electric field of a Nd:YAG laser. These strongly aligned samples are investigated in ion and electron time-of-flight and imaging experiments and throughout X-ray diffraction. In the molecular beam rotational temperatures on the order of 1 K are obtained. A very high degree of alignment of $\langle\cos^2\theta\rangle_{2D}$~=0.9 – probed by velocity map ion imaging – was demonstrated at LCLS. We confirmed that scattering signals could be acquired from the molecules, at a rate of less than a photon per pulse, with a beam density of hundreds of molecules intersecting with the focused pulse. Although the molecular structure was not observed, presumably due to a pulse duration that exceeded the damage timescale, this experiment shows the feasibility of recording signals from single macromolecular samples.

With the availability of hard and soft X-ray free-electron lasers we have now completed many of the proof-of-principle demonstrations of the necessary steps in the 3D diffractive imaging of reproducible particles. Already the research is opening up new vistas in structure and we will continue to extend imaging to further horizons.

Figure 5 on the right: 3D rendering of the structure factors of photosystem I obtained by femtosecond X-ray protein nanocrystallography.



CONDENSED MATTER DYNAMICS DIVISION

This division of the Max Planck Research Department for Structural Dynamics at CFEL (MPSD-CFEL) works on control of quantum condensed matter. It seeks to understand and to direct with light phenomena that to date have only been studied near equilibrium, such as superconductivity, charge density waves or complex magnetism. To this end, we use advanced nonlinear optical techniques, typically in the THz range, to drive complex many-body excitations into new states, which are not accessible thermally. These processes are then interrogated with fast X-ray pulses from free-electron lasers, synchrotrons and tabletop instrumentation.

Light-induced Superconductivity: One of the recent highlights has been the discovery of the "light-induced superconductivity" effect [*Science* **331** (2011) 189]. Indeed, one of the most intriguing features of some high-temperature cuprate superconductors is the interplay between one-dimensional, "striped", spin- and charge-order and superconductivity. We have used mid-infrared femtosecond pulses to transform one such stripe-ordered compound, non-superconducting $La_{1.675}Eu_{0.2}Sr_{0.125}CuO_{4,}$ into a transient three-dimensional superconductor. The emergence of coherent interlayer transport was evidenced by the c-axis optical properties. The timescale needed to form the superconducting phase was estimated to be 1-2 ps, significantly faster than expected, and placing stringent new constraints on our understanding of unconventional superconductivity in the cuprates. To understand this process we will be performing experiments at the Stanford Linac Coherent Light Source (LCLS), where we will interrogate the electronic and magnetic order with soft X-ray scattering whilst the system is turned into a superconductor, and clarify the relationship between the two phenomena.

Coherent Many-Body Dynamics in Electronic Insulators: In conventional solids, the interaction between electrons is considered negligible, and the macroscopic properties can be understood in terms of band theory. Such theory has been enormously successful and has guided us through, among other things, the development of semiconductor technology and the electronic revolution. When electrons feel the charge of other electrons, the mobility is determined by complex interactions within the electron gas, and as a result, the electronic structure is very sensitive to doping.

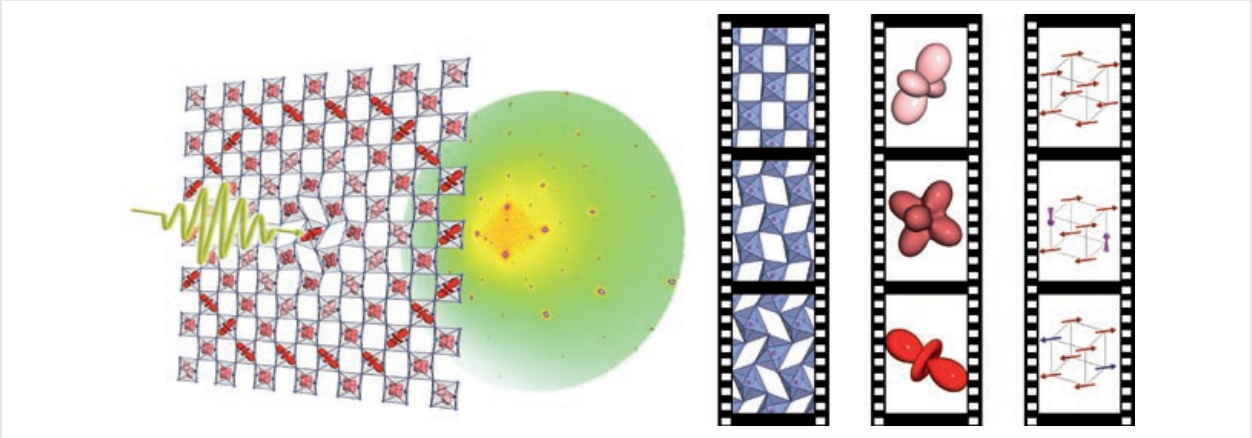
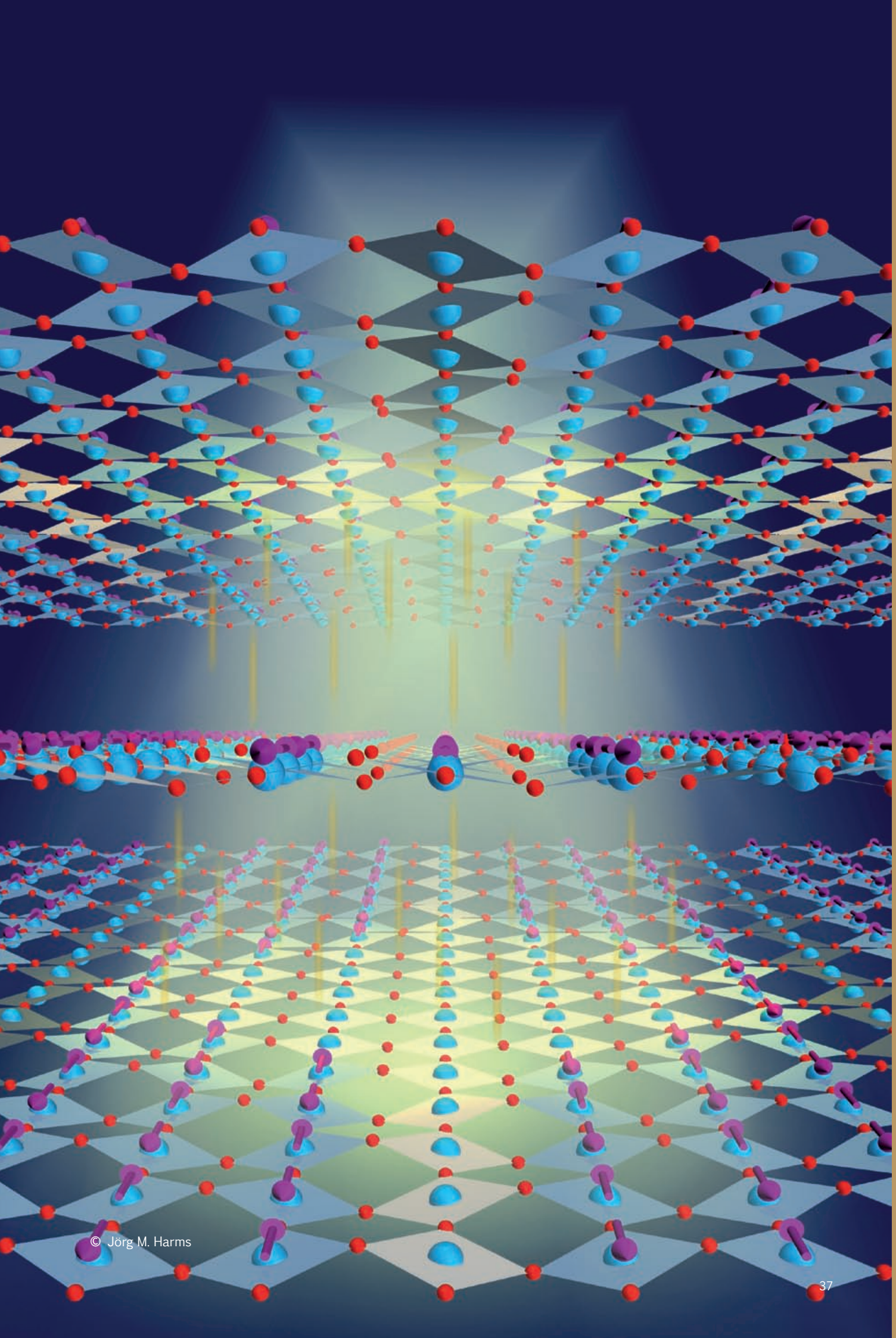


Figure 1: Sketch of a typical experiment carried out in the Condesed Matter Division: a short light pulse is used to deform the crystal lattice of a complex material. The induced dynamics are monitored through changes of the X-ray scattering pattern, which can be analyzed to take movies of the temporal evolution of the lattice, orbital, and magnetic degrees of freedom.

Figure 2 on the right: Side view of a layered copper-oxide insulator, exhibiting one-dimensional "stripes" of aligned spins and trapped charges within a buckled lattice. By irradiating one such striped compound with light it has transformed from an insulator to a superconductor within one millionth of a millionth of a second, freeing electrons from their traps and making it possible for them to tunnel in pairs between second neighbouring planes (the same stripe direction).



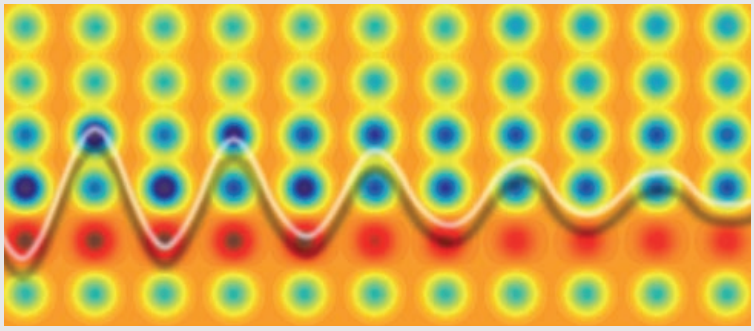


Figure 3: Simulated temporal evolution of the quantum interference between ionized and bound doublon-holon pairs after optical excitation of a Mott insulator (time axis from left to right). Electrons are not created with complete freedom to move, but are recurrently pulled back to the 'holes' they leave behind, forcing them to oscillations between the bound and ionized states.

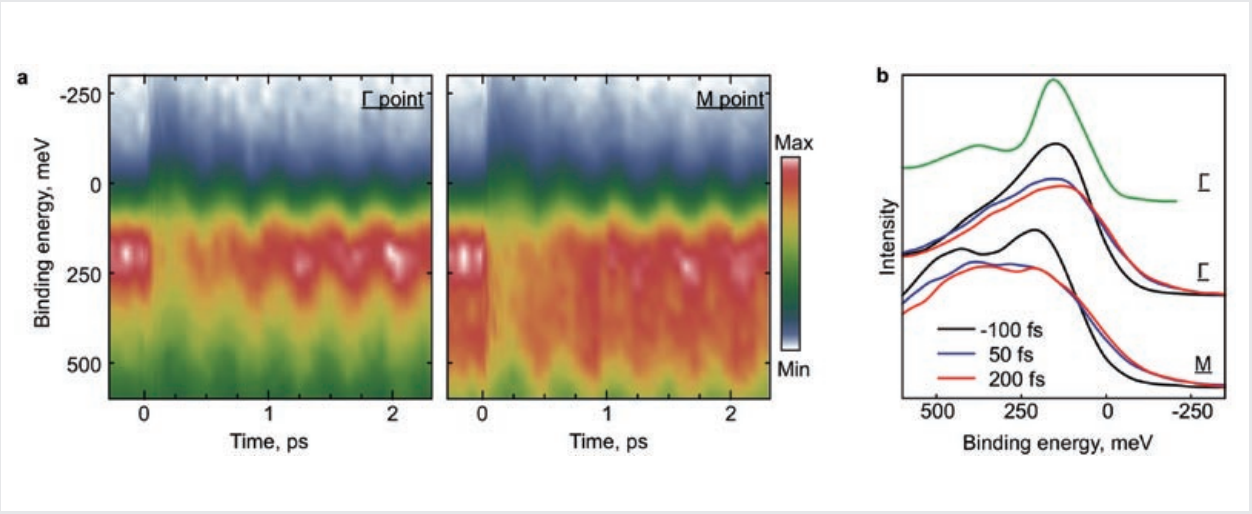


Figure 4: (a) Time-resolved maps of photoemission intensity at Γ– and M-point of the CDW compound after optical excitation. The collapse of the Mott gap is highlighted by the prompt transfer of intensity across the Fermi level (EB=0 meV) at different points of the Brillouin zone. The destruction of CDW order appears as the collapse of two distinct bands into a single feature. (see also panel (b), showing individual energy distribution curves before and after photoexcitation).

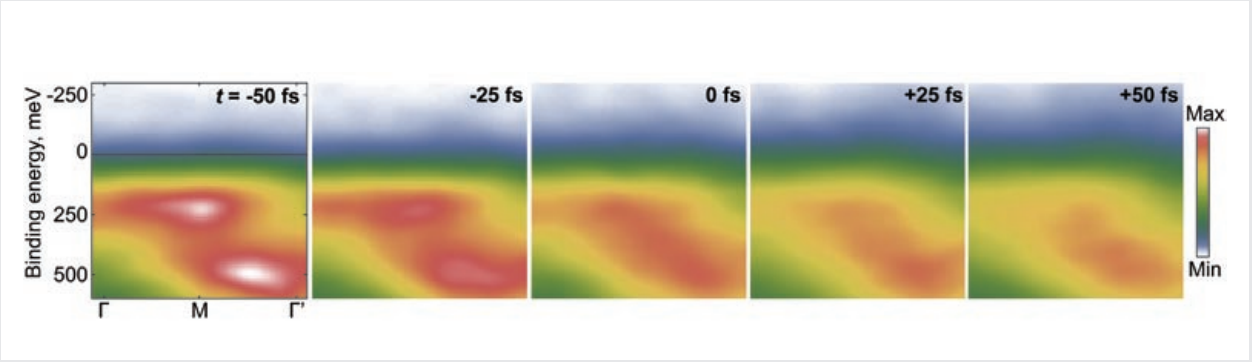


Figure 5: Snapshots of the momentum-dependent photoemission intensity at different time delays before and after excitation: As the insulator-metal transition proceeds, transfer of intensity across the Fermi level, i.e. the collapse of the Mott state, is evident throughout both Brillouin zones. Also, the band gap at the M-point, related to the CDW order, breaks down on sub-vibrational timescales.

Understanding doping of the Mott insulator is one of the grand challenges of modern condensed matter physics, as a bewildering variety of interesting quantum phases of matter emerge in this process, including, in two dimensions, high temperature superconductivity. Photoexcitation, which redistributes charge between sites, can control many-body processes in Mott insulators on the ultrafast timescale. Quantum many-body dynamics have only been detected in the controlled environment of optical lattices, where they are slower and lattice excitations are absent. By using near-IR pulses of extreme duration (<10 fs), we have measured coherent electronic excitations in the organic salt ET-F_2TCNQ, a prototypical one-dimensional Mott Insulator. We have measured oscillations in the spectroscopic response of these systems on extremely fast timescales, detecting coherent evolution of the many-body wave function, and singling out the physics of exotic quasi-particles called holons and doublons, which were found to determine the excitation of the system [*Nat. Phys.* 2010 advance online DOI: 10.1038/NPHYS1831].

Snapshots of electronic structural dynamics by Time and Angle Resolved Photo-emission spectroscopy: Charge density waves (CDW) underpin the electronic properties of many complex materials. Near-equilibrium CDW order is linearly coupled to a periodic, atomic-structural distortion and the dynamics is understood in terms of amplitude and phase modes.

However, at the shortest timescales lattice and charge order may become de-coupled, highlighting the electronic nature of this many-body ground state. Using time and angle resolved photoemission spectroscopy with sub-30-fs XUV pulses near 20 eV photon energy, we have mapped the time- and momentum-dependent electronic structure in photo-stimulated 1*T*-TaS_2, a two-dimensional charge density wave compound. Contrary to what was expected, we found that CDW order melted well before relaxation of the underlying structural distortion. These studies were combined with ultrabroadband optical spectroscopy to connect the physics of this unconventional photo-excited state with the polaronic transport in these transiently photometallic compounds [*Phys. Rev. Lett.* **106** (2011) 016401].

In the future, we plan to extend the studies of complex many-electron dynamics to few femtoseconds or even attosecond timescales, in a collaborative effort with the group of Adrian Cavalieri (see page 20).

Controlling magnetism through the lattice: Control of magnetism with light is of interest for high speed switching applications. To date all experiments have used eV photon energies to drive spin flips on tens of meV energy scales, resulting in excessive heating.
We demonstrated that magnetic order in $La_{1.5}Sr_{0.5}MnO_4$, a complex magnetoresistive manganite, can be disordered through excitation of an infrared active lattice distortion (600 cm-1, 80 meV). Femtosecond resonant soft X-ray diffraction, which was first demonstrated by our group using radiation from a synchrotron storage ring operating in low alpha mode, has been now performed at the LCLS X-ray free-electron laser. We have used this technique to clock the loss of antiferromagnetic order after lattice excitation. Switching through lattice excitation in the mid-infrared, limited in speed by spin lattice relaxation rates, is also found to be more efficient than in the near infrared.

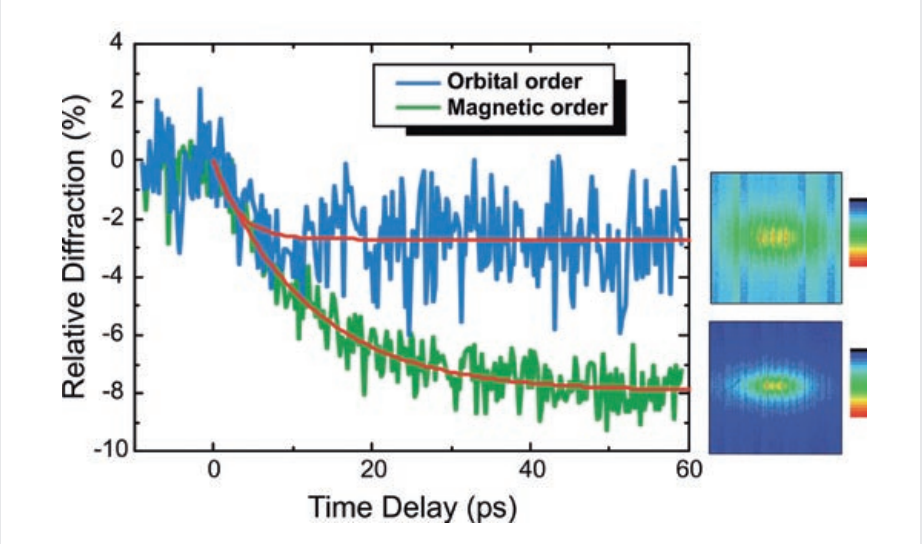


Figure 6: Time-resolved resonant soft X-ray diffraction on a manganite compound after mid-infrared excitation. Measurements at the LCLS free-electron laser demonstrate ultrafast lattice-induced melting of orbital and magnetic order. The upper panel shows the scattering geometry and the diffracted spot intensities for the (1/2, 1/2, 0) and (1/4, 1/4, 1/2) wave vectors, which probe orbital and magnetic order, respectively.

ATOMICALLY RESOLVED DYNAMICS DIVISION

The Atomically Resolved Dynamics Division officially started on July 1, 2010 with R. J. Dwayne Miller taking up the position as Division Leader. Since this time, laboratories have been renovated in the cyclotron building of the University of Hamburg and the original DESY LINAC 1 Hall to accommodate the research program that primarily focuses on the development of ultrabright electron sources. Research is also being conducted jointly at the University of Toronto to keep this program advancing as much as possible as the group is being built up in Hamburg.

"Making the Molecular Movie" –
First Frames and First Surprises

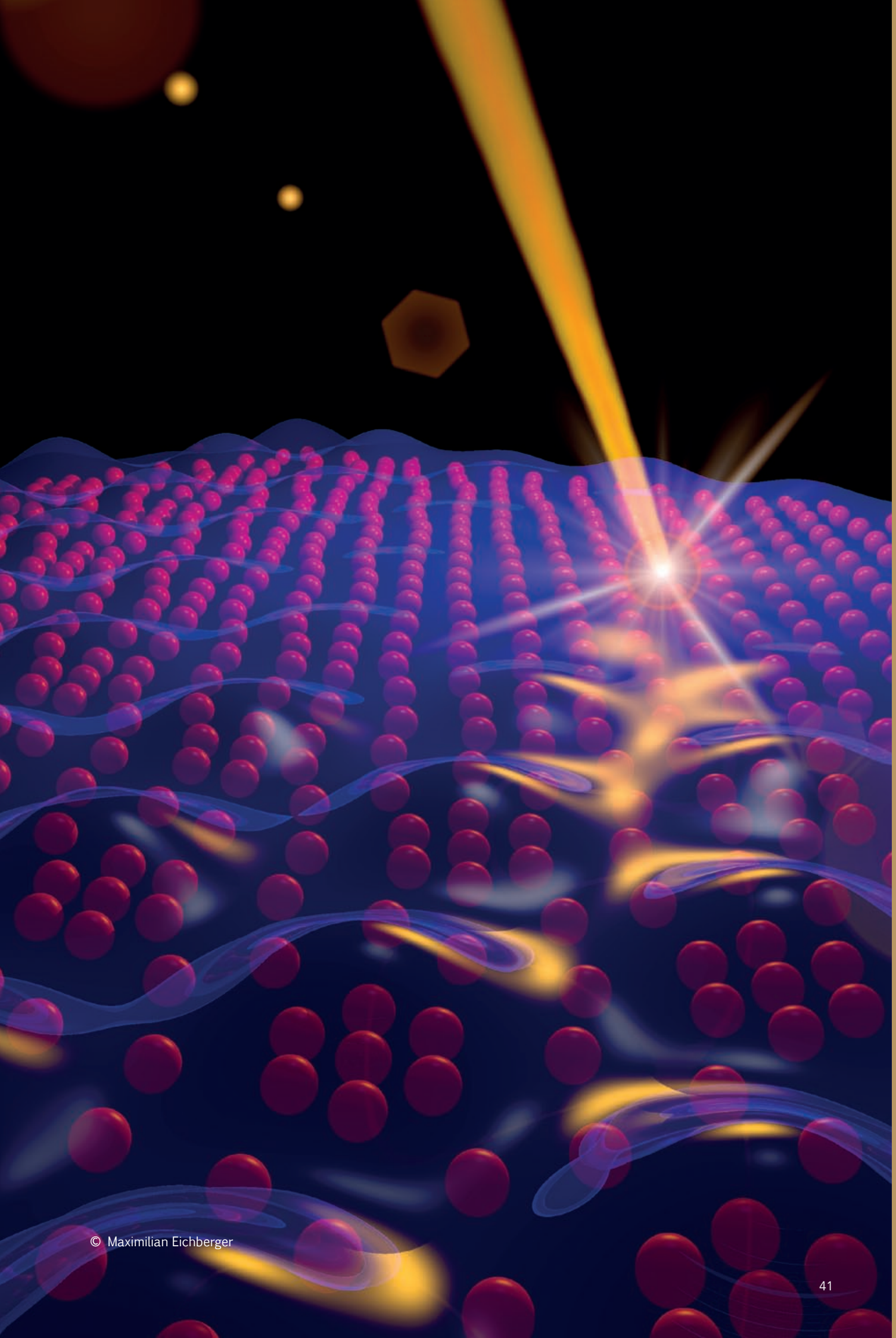
One of the long sought objectives in science has been to directly watch atomic motions during structural changes. This objective requires extremely high spatial resolution (<.1 nm) and temporal resolution (100 femtosecond time scale) with sufficient source brightness to fully resolve the dynamics of interest. In this space-time limit, it is possible to directly observe chemistry as it happens, to follow the primary events driving biology, and to separate electronic and nuclear factors in studying strongly correlated electron-lattice dynamics. This level of acuity makes it possible to directly determine the anharmonic couplings, common to all dynamical problems, in a single measurement. The importance of this problem is one of the drivers for CFEL and has been emphasized throughout this report. The Miller group was the first to achieve atomically resolved structural dynamics in the required subpicosecond domain through the development of what can be considered "ultrabright" nonrelativistic electron sources to light up the atomic motions. At the atomic level of observation, we have now reached what can be considered the fundamental limit to following structural dynamics.

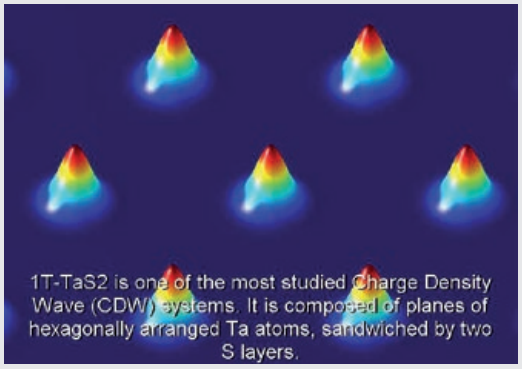
This level of acuity has revealed a number of surprises. The first report focused on the simplest structural transition possible, that of melting, albeit under rather unusual conditions of a strongly laser-driven phase transition [*Science* **302** (2003) 1382]. The first surprise was that the material melted from the "inside-out" in a process known as homogeneous nucleation rather than the conventional melting from the "outside-in" as for example in the everyday experience of melting ice. In the process, it was possible to literally watch bonds break and the lattice shake itself apart, forming nucleation sites or liquid domains that remained on the nm or molecular level.

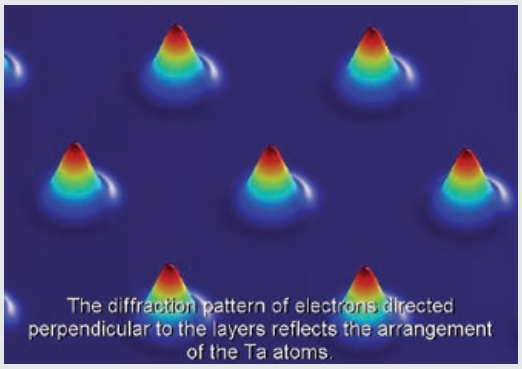
As much of a pure curiosity that this observation may seem, this simple finding demonstrated the physics needed to selectively excite and remove material without the formation of macroscale nucleation sites and associated cavitation with shock wave induced damage. A new concept in laser surgery was developed along with a novel solid state laser concept that made it possible to selectively energize water in biological tissues and remove soft tissue without damage to surrounding tissue [*Opt. Express* **17** (2009) 22937; *Phys. Chem. Chem. Phys.* **12** (2010) 5225]. This laser concept has now achieved the fundamental limit to surgery and most important without apparent scar tissue formation [*PLoS* **5** (2010) e13053]. This discovery could be a significant breakthrough as scar tissue leads to complications in all surgeries and loss of function to some degree. In some cases, full function is not recovered. This latest advance opens up the prospect of surgery with near perfect healing at the single cell level of precision. This advance came from the basic research program but has far reaching implications for both surgeries and biodiagnostics. A unique collaboration with University Medical Center Hamburg-Eppendorf (UKE) medical researchers has been formed to fully explore the medical applications with a new laboratory built at the UKE to facilitate translation of these finding to clinical applications.

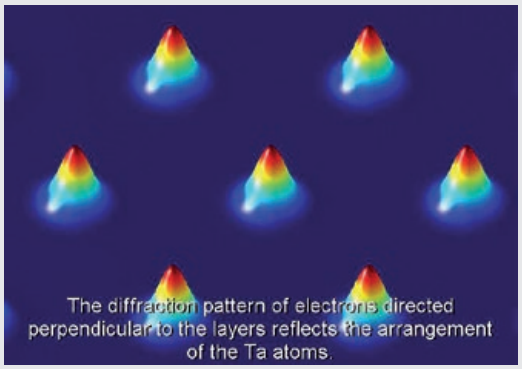
Since this first report, the group has continued to increase the source "brightness" by increasing the bunch charge and minimize momentum spread. They have achieved single shot structure determinations with time resolution better than 200 fs. On this timescale, the lattice is essentially frozen. The use of femtosecond laser excitation makes it possible to change the electron distribution and directly observe the changes in the potential energy landscape of the lattice, i.e. the affect on the fundamental bonding in the lattice. Under extremely high excited electron distributions, it was possible to track the formation of Warm Dense Matter and discover that a nascent liquid state is involved as well as evidence for bond hardening in Au [*Science* **323** (2009) 1033].

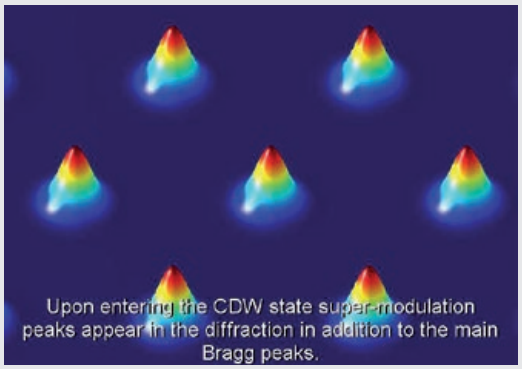
Figure 1 on the right: Key concepts observed with the first atomic view of the order parameter for Charge Density Wave formation in TaS_2 as an example of strong electron-lattice coupling. The excitation processes led to a highly cooperative response in which the light effectively 'becalmed' the Charge Density Waves within fundamental limits for correlated atomic motions.

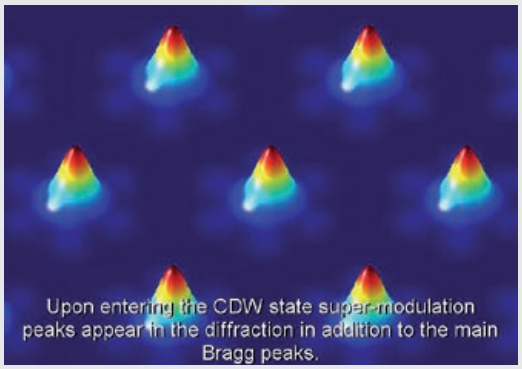












This latter observation is surprising as almost all materials become softer when excited (e.g. metals become more malleable upon heating). Here the lattice was becoming harder not softer. This process is only observable under the incredibly fast time scale of these observations and is in agreement with recent time dependent density functional calculations. Studies of the Peierls distorted lattice of Bi also gave some surprises. It was found that when up to 10% of the valence electrons were excited, the lattice was transformed into a true liquid in less than ½ period of a lattice vibration [*Nature* **458** (2009) 56]). This work constitutes the first observation of ballistic melting, melting without collisions, and one of the fastest structural changes ever measured. The motions involved are larger in amplitude and faster than the cis to trans isomerization step of vision that was the fastest structural change known until this finding. This work was further extended to even more strongly coupled electron-lattice systems in following the highly cooperative response of Charge Density Waves to perturbations in the electron distribution as exemplified by TaS_2 [*Nature* **468** (2010) 799]. Here again there as a surprise. It was possible to directly observe the structure order parameter in which the supermodulation of the lattice (Charge Density Wave) collectively responded to the electron perturbation. The laser excitation literally becalmed the Charge Density Waves, and as soon as the excitation was transduced to acoustics not matching the order parameter, the system immediately latched back to the supermodulation in an incredibly cooperative response. The quality of data, and full in-plane reconstitution of the atomic motions along the key coordinates made possible with electron diffraction, illustrates the importance of this new tool for studying highly cooperative effects that in turn could lead to new material properties.

For the full story please refer to the review: “Making the Molecular Movie: First Frames” by R. J. D. Miller, R. Ernstorfer, M. Harb, M. Gao , C. T. Hebeisen, H. Jean-Ruel, C. Lu, G. Moriena, G. Sciaini [*Acta Cryst. A* **66** (2010) 137].

Quantum State Dynamics – New Coherent Multi-dimensional Spectroscopies Light Up Correlations

The wave function of matter is usually written with the electronic contributions separated from the nuclear in the classic Born-Oppenheimer approximation. This approximation is valid in most cases based on the clear separation in time scales for electron and nuclear motions. For thermally sampled coordinates, the electrons adiabatically follow the nuclear motions. The coupling to the bath and irreversible structural dynamics are determined

by the time sale of the nuclear fluctuations. This approximation breaks down at conical intersections in which the change in electron distribution dictates the time scales for the structural dynamics. For optically excited systems, as discussed above, changes in the electron distribution are well above kT and persist long enough to affect nuclear motions. With atomically resolved dynamics, we have the perfect probe to connect this correlation between electron and nuclear coordinates. Independent information on the quantum state or electronic degrees of freedom can be obtained by conventional time resolved spectroscopy. The problem has been that the optical signatures are often obscured by the classic problem in spectroscopy of inhomogeneous broadening. The Miller group has developed a fully general optical analogue of NMR in which Coherent Control pulse shaping protocols have been implemented in a newly discovered interferometer design that is passively stabilized against phase noise (path length variations) [*Opt. Express* **17** (2009) 9764, *Acc. Chem. Res.* **42** (2009) 1442]. This new concept has made is possible to execute the same kind of coherence transfers among states as done in NMR but rather than spins, the relative phases and coherences of electronic states can be manipulated. The energy range of the states manipulated is in the range of chemical bonds. In this case, the objective is not to determine structure as in NMR (structural information is obtained via electron structural probes) but to manipulate the phase of the electronic wave function and thereby control dynamics and chemistry. This approach gives specific information on the phase of the wave function. It has also been shown that it is possible to control quantum decoherence to a certain degree by controlling the state preparation. This approach has been used to study the photoisomerization of bacteriorhodopsin in which electronic state evolution through the conical intersection has been manipulated. By virtue of the ability to rephrase the coherence, it has also been possible to selectively tag a frequency/state and directly monitor the state evolution through a conical intersection even for systems as complicated as biological molecules. This work has led to fundamental new insight into the difference between closed and open quantum systems with respect to weak field coherent control and has important implications in understanding the role of the bath in controlling reaction dynamics.

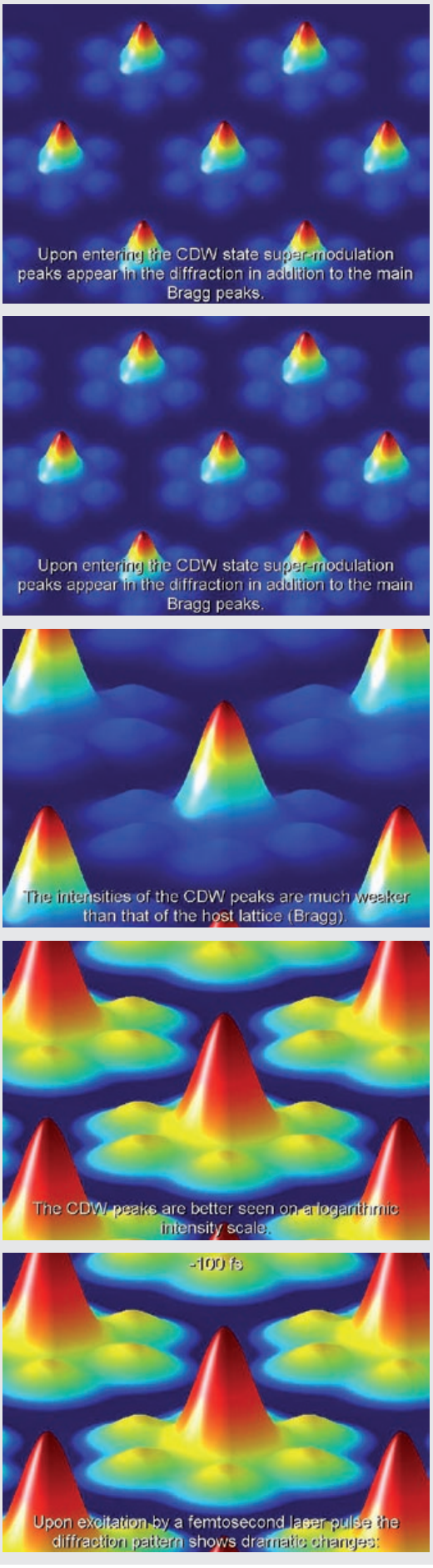
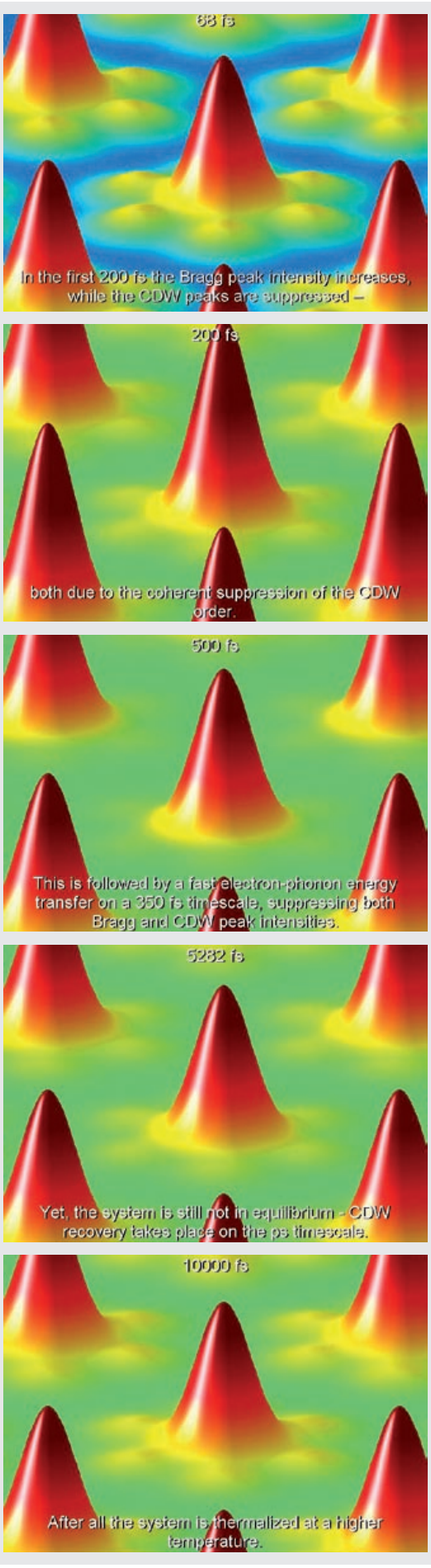


Figure caption for all figures: Single frames from the movie from M. Eichberger, H. Schäfer, G. Sciaini et. al. [Nature 468 (2010) 799] as supplementary information available at http://www.nature.com/nature/journal/v468/n7325/full/nature09539.html#/supplementary-information.



Future Prospectus

The above discussion gives the ongoing activities of the group. There are four new labs being built up that are slated to come on line by the summer of 2011. One lab is dedicated to the development of a relativistic electron gun to increase the electron bunch density by an order of magnitude and push the time resolution down to less than 50 fs. This facility is also being used as a test bed for electron gun development and electronic synchronization that will be of benefit to the European X-FEL. Two other nonrelativistic electron guns will provide the ability to study gas phase and surface reaction dynamics. The fourth lab focuses on quantum state dynamics and will be the home to a full suite of optical wavelengths ranging from the UV to IR with full control over electric fields with few femtosecond time resolution and multidimensional capabilities to provide complementary frequency/quantum state correlation information.

The research program has been focusing on solid state physics issues as test cases towards the ultimate goal of studying the structure-function correlation in biological systems. The new high brightness electron guns will now enable the study a number of biological systems and effectively open up nearly all chemical reaction dynamics to exploration with electron structural probes. The electron source development is highly complementary to the FEL scientific focus. There are certain systems that can not be studied with electrons due to constraints in sample conditions. Here X-rays are the only choice. To enable exploitation of the full brightness of 4th generation light sources, the group has developed a photocrystallography chip concept that makes it possible to mount up to 1 M microcrystals in an ordered array within seconds [*Anal. Chem.* 2010 in press, DOI: 10.1021/ac1021024]. This latter development could be quite important in opening up both the study of nanocrystals but also time resolved studies using X-FELs in which a minimum basis of some 10,000 protein crystals (or different locations) are needed to construct a full time sequence of motions at the atomic level of resolution. Recent beam time at the LCLS in collaboration with the Schlichting group (MPG-ASG) has shown that it is possible to use the full brightness of the X-ray source with this new chip concept. The first femtosecond time resolved protein structural dynamics were conducted as well as the first step towards resolving the structure-function relationship in biological molecules.

Figure caption for all figures: Single frames from the movie from M. Eichberger, H. Schäfer, G. Sciaini et. al. [Nature 468 (2010) 799] as supplementary information available at http://www.nature.com/nature/journal/v468/n7325/full/nature09539.html#/supplementary-information.

FINITE QUANTUM SYSTEMS, COHERENT IMAGING & FOREFRONT INSTRUMENTATION

MAX PLANCK ADVANCED STUDY GROUP

The Max Planck Advanced Study Group (MPG-ASG) at CFEL pursues science at the full breadth enabled by FELs: Exploring the (non-linear) interaction of the FEL radiation with individual ions, atoms and molecules, tracing of chemical reactions, investigating large but finite quantum systems such as clusters, and coherent imaging of biological samples. The experimental program, with a suite of novel and dedicated instruments operated at FLASH (Figure 1) as well as at LCLS (page 29), is strongly supported by theory. A selection of recent highlights is presented here.

The "last cry of matter", heated to millions of degrees in an accretion disk before disappearing forever in a black hole, is X-ray light emitted or absorbed by the highly ionized plasma near the event horizon. At FLASH, ASG researchers exposed for the first time such hot but dilute matter, produced and confined in an electron beam ion trap (EBIT), to the intense VUV radiation, and studied its absorption with unprecedented accuracy [*Phys. Rev. Lett.* **98** (2007) 183001]. In this way not only important data for astrophysics can be recorded but, in addition, the most precise theory in physics, quantum electrodynamics, can be tested in a regime called non-perturbative, which has not been accessible before with such accuracy. In February 2011, even hotter matter will be illuminated by hard X-rays from the

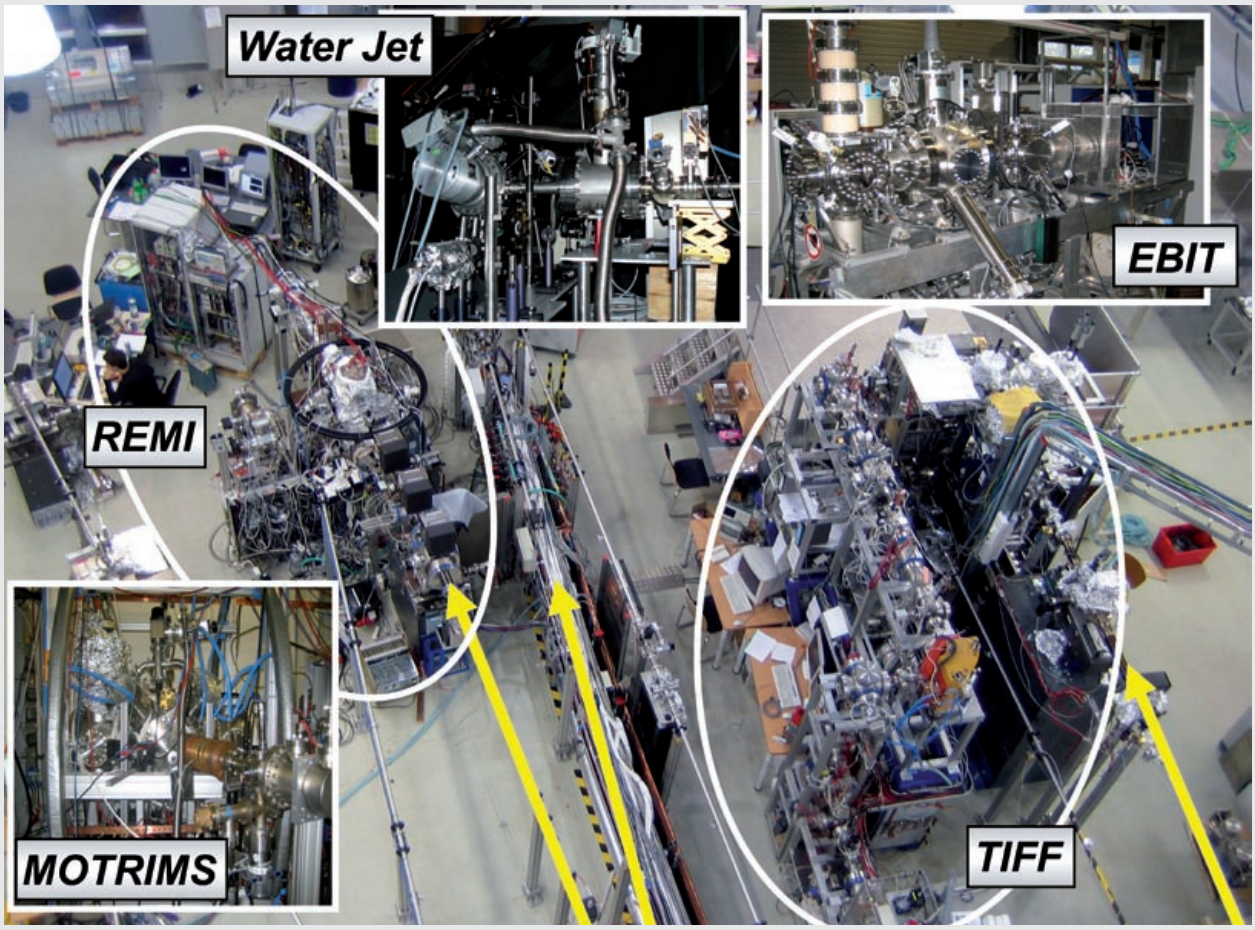


Figure 1: ASG-instrumentation at FLASH: A trap for hot plasmas (EBIT), a reaction microscope (REMI), a magneto-optical trap spectrometer (MOTRIMS), a molecular ion facility (TIFF) and a water jet.

LCLS, heralding a new era in research enabled through the unprecedented FEL photon flux!

The first molecule in the universe was HeH^+! While details of its formation are still in the dark, it is safe to say that it had to struggle for survival from the very beginning: Radiation flooding all of space could cause dissociation and thus, its destruction. Making use of the huge photon flux at FLASH, ASG scientists had a first glimpse of this process finding and characterizing pathways hitherto completely missing in theory [*Phys. Rev. Lett.* **98** (2007) 223202]. With the TIFF apparatus, molecular ions of many types can be cooled and prepared in well-defined quantum states and emerging photofragments can be fully characterized (mass, velocity and emission direction). This allows not only unraveling their light-induced destruction mechanisms but, moreover, provides information on their structure for a wide variety of samples. They include simple molecules like protonated water [*Phys. Rev. Lett.* **105** (2010) 253003] or water complexes which are important for the chemistry in upper planetary atmospheres, polycyclic aromatic hydrocarbons found in interstellar clouds, mass and size-selected cluster ions, biomolecules or even dust grains, thus opening a whole new field of research.

Observing chemical reactions in real-time at femtosecond resolution is one of the most promising research areas envisioned at the FELs. Using a "reaction microscope" (REMI), ASG researchers determined the ultrashort time span that is needed for a so-called isomerization reaction, which is essential in eye vision or photosynthesis. This was an elusive aim sought after for thirty years. The decisive tool, a REMI, allows tracing masses, velocities and emission directions of all fragments [*Phys. Rev. Lett.* **102** (2009) 123002]. Here, data show how in a singly ionized acetylene molecule one proton moves from one end to the other , forming vinylidene in just about 50 fs [*Phys. Rev. Lett.* **105** (2010) 263002].

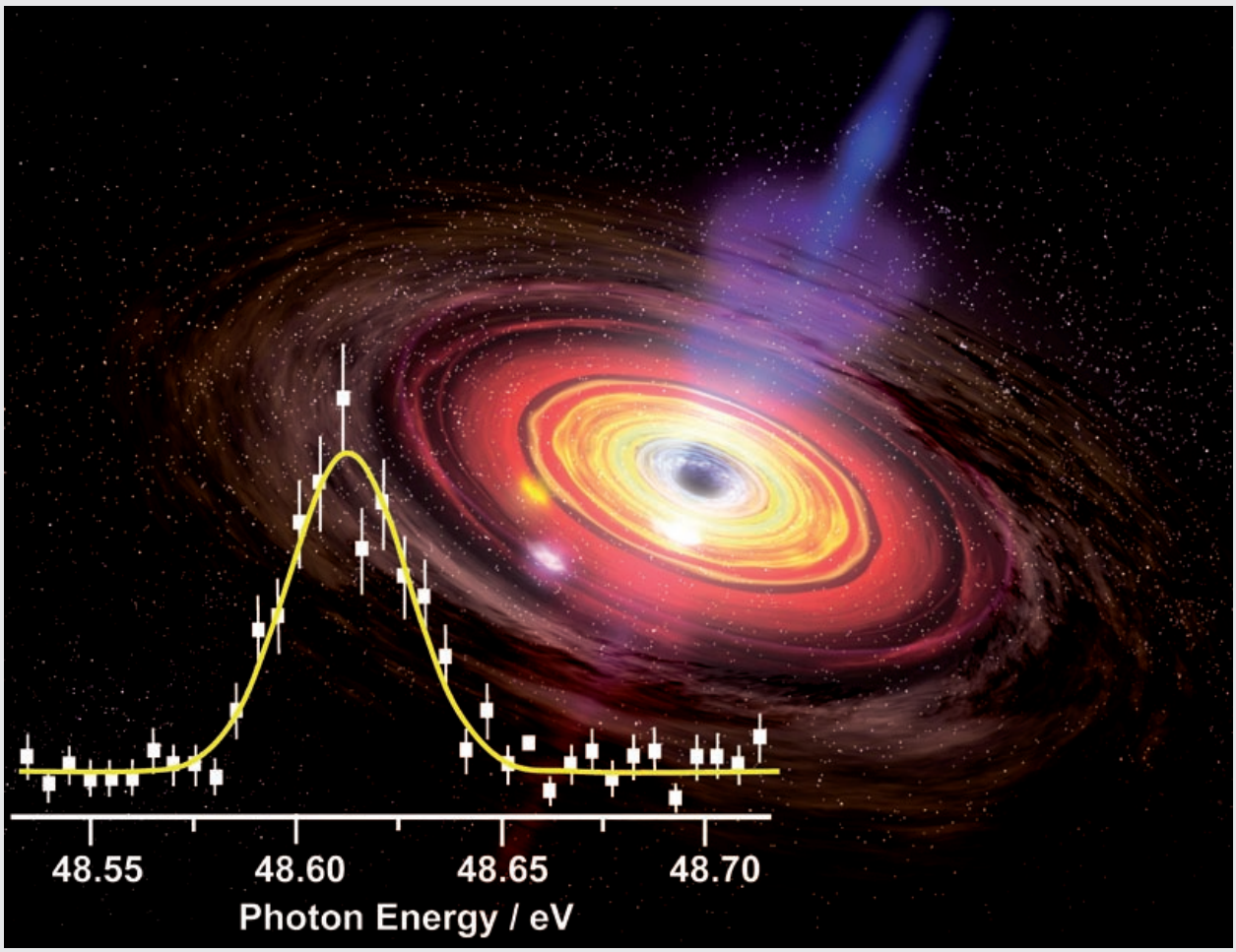


Figure 2: Illustration of a black hole and its accretion disk in an active galactic nucleus, and an inverse absorption spectrum of 23-fold charged iron ions as measured at FLASH.

Unexpectedly, a novel split mirror technology provided time resolution only limited by the coherence length of the FEL radiation. Spikes as sharp as 4 fs were observed [*Phys. Rev. A* **82** (2010) 041403], and explained theoretically [*Opt. Lett.* **35** (2010) 3441], even though the pulse envelope is much longer. This points to the exciting possibility to reach attosecond time-resolution in similar experiments anticipated at the LCLS. Here, a large international collaboration led by ASG scientists took first images of aligned molecules by inspecting the diffraction of emitted photoelectrons as a function of time. This technique, called "photoelectron holography" is expected to provide femtosecond snapshots of moving atoms in a chemical reaction with sub-Å position resolution.

The characterization of chemistry in its real time dynamical complexity ("from local to global") has been one of the driving forces for building FELs. Knowledge of these properties will enable designing new functional materials like molecular fast switches. Extracting (time-resolved) crystallographic information on complex chemicals was demonstrated for the first time at FLASH for an organometallic compound with a lamellar structure similar to the ones of nanotubes or liquid crystals, all of significant importance for a variety of applications [*Phys. Rev. Lett.* **104** (2010) 125503]. Pioneering time-resolved experiments on the periodic reflectivity change of organic polymer foils as well as of water [*J. Phys. B.* **43** (2010) 194009] pave the way for observing structural dynamics during chemical reactions in complex molecular compounds, in liquids or for surface catalysts. Monitoring structure on the Ångstrom scale is expected at X-ray energies where ASG researchers watched electron solvation dynamics at the LCLS.

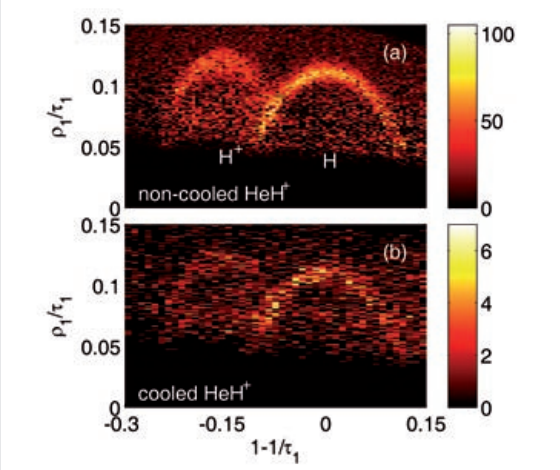


Figure 3: Fragment momentum distributions from (un-)cooled HeH^+ after FLASH VUV photo absorption.

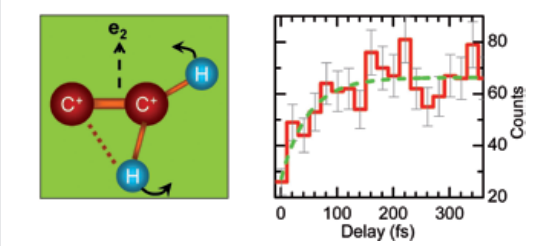


Figure 4: Real-time observation of photon induced isomerization from acetylene cations $[H\text{-}C{\equiv}C\text{-}H]^+$ to vinylidene $[C{\equiv}C\text{-}H_2]^+$.

One of the holy grails of research envisioned at X-ray FELs is to determine the atomic structure of non-crystallizable and / or non-reproducible biomolecules or complexes like membrane proteins, bacteria, viruses or cells. Time-resolved measurements will give direct access to study biology or biochemistry in action. Beyond being of biological interest where one ultimately seeks to understand how these units function, such studies constitute one essential building block towards producing new medicines or drugs. Being one of the driving goals of the ASG from the beginning, the unique bundling of multidisciplinary ASG expertise and technology enabled creating the CAMP instrument (see 29). Combined with world-leading experience in the Coherent Imaging Division, CFEL groups took the lead in this high-impact field of FELscience in the first year of LCLS operation.

In addition to operating CAMP, ASG researchers concentrated on investigating sub-micron lysozyme crystals and T4 viruses as test cases. With its structure well known since decades, millions of pictures of individual lysozyme nanocrystals were taken, combined, indexed and integrated, yielding an amazing and extraordinarily important result: The recorded sub-nanometer resolution diffraction patterns correlate extremely well with conventional synchrotron data even though the crystals are completely vaporized within some tens of femtoseconds after exposure to the FEL beam.

Whether the above still holds true if one goes to even shorter wavelengths to achieve atomic resolution is an open question. Nonetheless, a mechanism discovered by the ASG theory group might be of decisive help: Microscopic calculations for clusters revealed ultrafast field ionization and electron migration towards the center of the cluster after substantial ionization of the sample in

the rising edge of the X-ray pulse [*Phys. Rev. A* **79** (2009) 041201]. Thus, positive charges in the inner part (up to the lower white line in Figure 7) of the cluster are shielded whereas the outer rim (in between the white lines) becomes highly charged and explodes with significant consequences on diffractive imaging. Surrounding the probe with a "sacrificial layer", or tamper, of helium atoms leads to a substantial improvement of the diffraction image for the embedded objects.

In summary, the flexible, interdisciplinary organization of the virtual MPG-ASG department with a stable anchor point of experts in Hamburg has proven extraordinarily beneficial for pursuing forefront research at FELs. Pioneering cutting edge science in several emerging fields at the border of knowledge promises exciting results in the upcoming years.

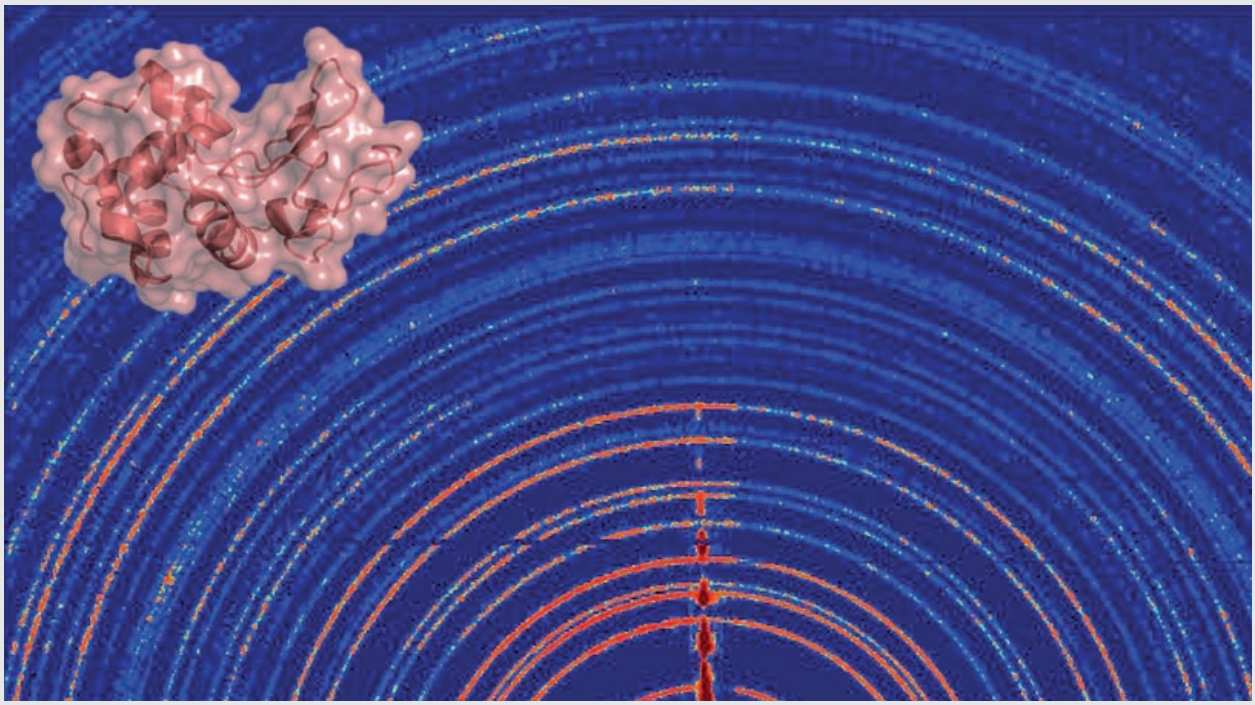


Figure 5: Lysozyme structure (upper left) and virtual powder diffraction pattern assembled from millions of individual nanocrystal diffractions.

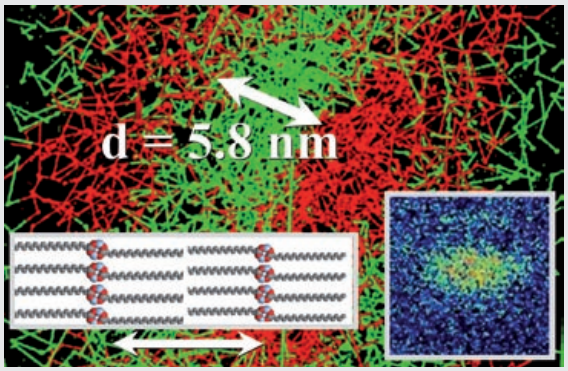


Figure 6: Silver behenate (structure left inset) with a 5.8 nm periodic spacing between the lamellar features. Measured Bragg peak (right inset).

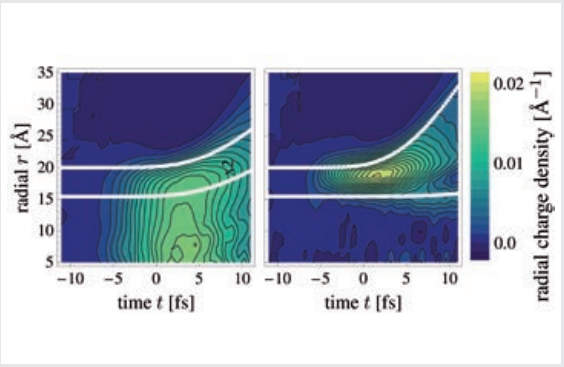


Figure 7: Radial charge density plot for a Ne_{1500} cluster and T=10 fs pulse with (right) and without (left) field ionization (see text).

FUNDAMENTAL LIGHT-MATTER INTERACTION, ULTRAFAST SCIENCE, ACCELERATOR-BASED LIGHT SOURCES

UNIVERSITY OF HAMBURG ADVANCED STUDY GROUP

The Advanced Study Group of the University of Hamburg (UHH-ASG) at CFEL pursues a wide variety of scientific goals which are enabled by the new free-electron laser sources. Among those goals are the exploration of the fundamental light-matter interaction induced with short wavelength (Extreme Ultraviolet (XUV) and Soft X-rays) radiation, the study of the ultrafast dynamic response induced by light in atoms, molecules, clusters and solids, and the development of innovative concepts for accelerator-based light sources and imaging particle detection. The experimental program includes work on innovative instrumentation at FLASH as well as at LCLS. A selection of recent key instrumental developments as well as scientific highlights is presented here.

A few-femtosecond X-ray streak camera has been realized [*Nat. Photonics* **3** (2009) 523] using a pump–probe scheme that samples the transient response of matter to ionizing soft X-ray radiation of FLASH in the presence of an intense terahertz field produced by the same electron bunch as the soft X-ray pump pulses and thus being fully synchronized. Borrowing its concept from attosecond metrology, the femtosecond X-ray streak camera fills the gap between conventional streak cameras with typical resolutions of hundreds of femtoseconds and streaking techniques operating in the sub-femtosecond regime. The camera allows single-shot characterization of soft X-ray pulses from FLASH in terms of their duration and time structure. For several classes of experiments in time-resolved spectroscopy, diffraction or imaging envisaged with novel accelerator- and laser-based short-pulse X-ray sources this knowledge is essential, but so far presents a major challenge to X-ray metrology.

Also for the characterization of FLASH pulses and for XUV-XUV pump-probe experiments an XUV beam splitter and autocorrelator has been developed which is based on a Mach-Zehnder-type interferometer and is integrated in the monochromator beamline at FLASH. With this device the longitudinal coherence of individual FLASH pulses as well as the pulse duration has been determined [*Opt. Lett.* **35** (2010) 372] which is important information for all time-resolved experiments and for coherent imaging with FEL pulses. Furthermore the device has been used to study molecular wave packet dynamics induced by XUV excitation.

The quest to understand non-equilibrium dynamics induced by transient light fields is one of the key research topics of the UHH-ASG. Recently two important scientific results have been obtained in this area. Using time-resolved X-ray emission spectroscopy electronic structure maps of silicon have been taken after optical excitation of electrons and creation of a non-equilibrium hot electron distribution. In the transient electronic structure maps monitoring the ultrafast response of the system a metastable liquid phase has been identified [*Proc. Natl. Acac. Sci. U S.A.* **107** (2010) 16772]. This low-density liquid phase which converts into the thermodynamically stable high density liquid phase in a first-order phase transition is very important to understand the peculiarities of liquids like for example water, where the liquid has a higher density as the corresponding solid.

In cooperation with the University Kiel the first direct measurement of charge-order dynamics in a strongly correlated material with combined femtosecond time resolution and chemical, elemental, and atomic-site sensitivity has been performed [*Phys. Rev. Lett.* **105** (2010) 187401], thereby establishing the technique of time-resolved core-level photoemission spectroscopy at FLASH. In the future, this technique will also enable to create detailed movies of local electron dynamics. These movies will not only help to unravel ultrafast phase transitions in correlated materials, but will also allow to monitor chemical reactions on solid surfaces in real time.

An area where the University is particularly strong is the research on innovative concepts for accelerator based light sources. The seeding experiment “sFLASH” (Markus Drescher and Jörg Roßbach) which is funded within the framework of the BMBF priority program FSP-301 has started operation in 2010 and is now in the commissioning phase. Jörg Roßbach and his coworkers are also pursuing two new projects where the focus is on the crea-

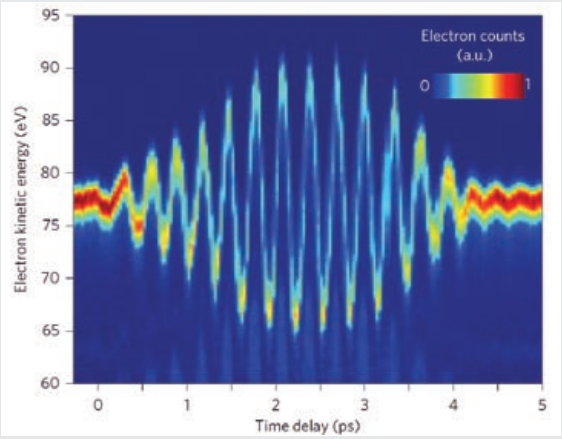


Figure 1: Series of kinetic energy spectra of 4p photoelectrons detached from krypton atoms by 13.5-nm soft X-ray pulses in the presence of an intense pulsed terahertz field. The energy shift of the electrons versus the X ray/terahertz delay directly represents the vector potential of the terahertz field.

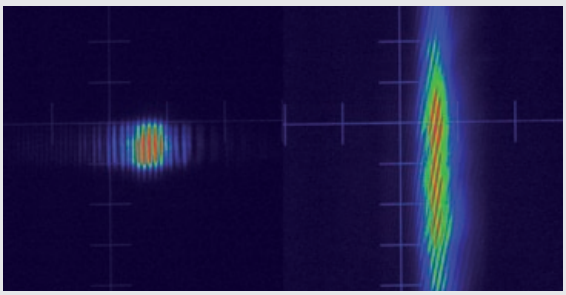


Figure 2: Interference fringes in zero order (left) and first order (right) of the grating imaged in the exit slit plane of the plane-grating monochromator at FLASH.

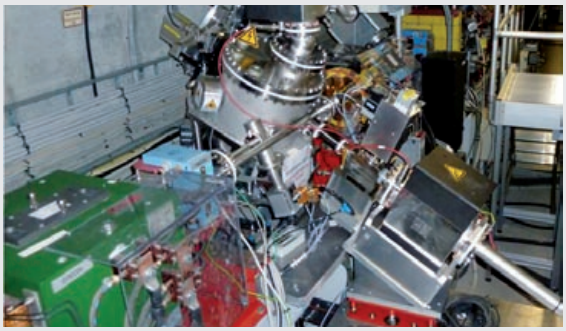


Figure 3: Mirror chamber for injection of VUV-seed-pulses into the FLASH accelerator. The electron beam comes from behind, while the VUV-seed-pulse is injected from a lower position on the right side.

tion of extremely short X-ray pulses at FLASH (sub-10 fs) either through seeding with high harmonic laser sources or through the production and manipulation of ultrashort electron bunches. All these developments are key to enhance the possibilities for ultrafast science at the free-electron laser sources.

The Advanced Study Group of the University has built the monochromator beamline at FLASH which enables experiments where the spectral content of the FEL pulses has to be well defined as in scattering and coherent diffraction with resonant excitation or high-resolution spectroscopy. Especially for high-resolution spectroscopy a new RAMAN spectrometer has been developed as a permanent endstation at one of the branch lines of the monochromator by the group of Michael Rübhausen. This spectrometer which is in operation since 2009 is used for inelastic scattering experiments with unprecedented resolution in the XUV- and soft X-ray regime.

Members of the UHH-ASG (Robert Klanner and his group) are partners in the development of fast X-ray imaging pixel detectors for the European X-ray free-electron laser. This is a key development for all experiments at the European X-FEL since it will allow scientists to take single shot images at an unprecedented rate enabled by the superconducting technology of the linear accelerator.

In summary, the flexible and open structure of the UHH-ASG department within CFEL is a nucleus for science with FELs at the University of Hamburg and provides a stable platform for the further development of interdisciplinary science with the new sources for all interested departments of the university. The fore-front research which is pursued ensures excellence in FEL science in the upcoming years. This will be further strengthened by establishing junior research groups in the aforementioned scientific areas which should provide excellent young scientists unprecedented opportunities to perform science with FELs.

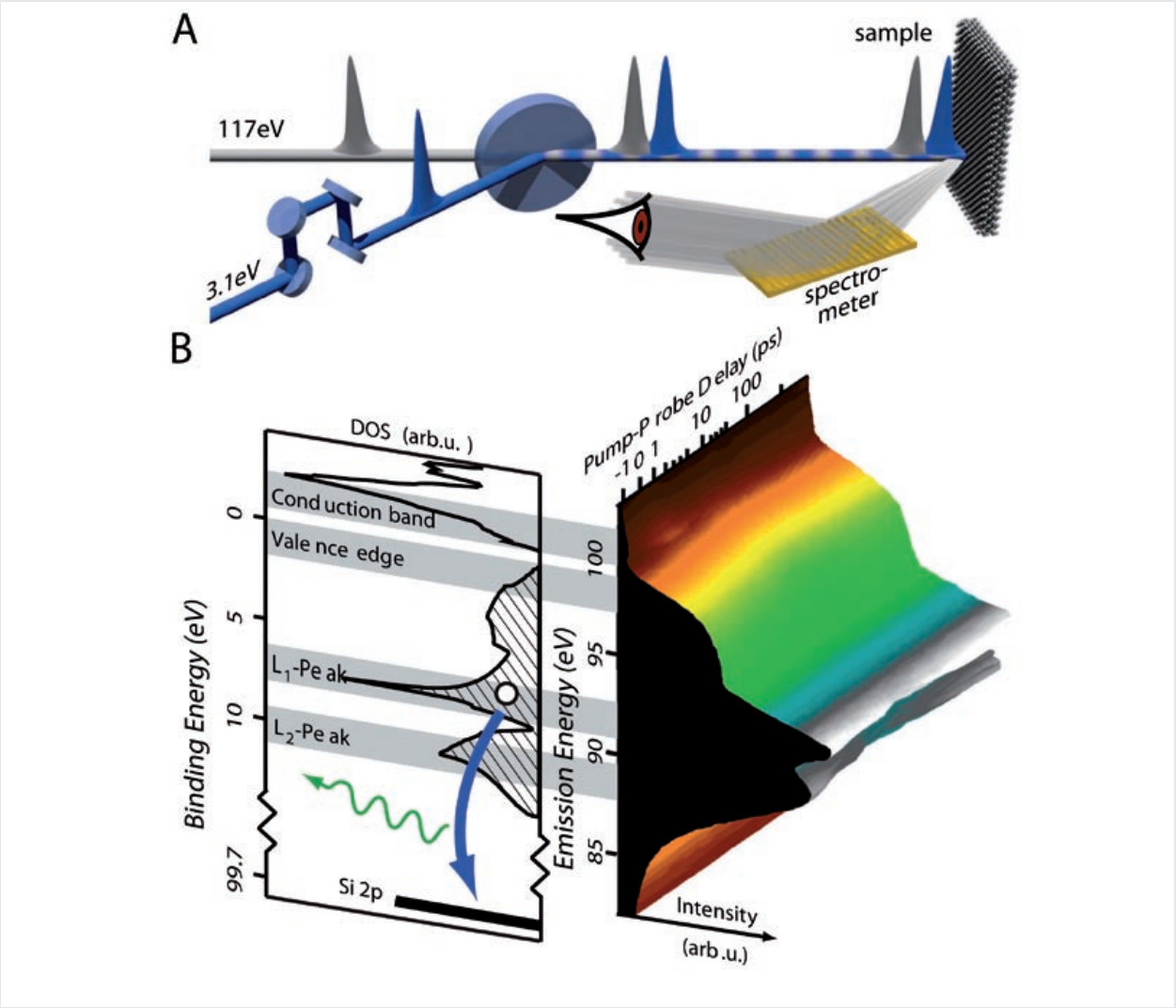


Figure 4: (A): Strong optical pump laser pulses (blue) induce a non-equilibrium electron distribution in the silicon sample. The evolution of the electronic structure is monitored by probing with soft X-ray pulses (gray) and analyzing the X-ray emission with a grating spectrometer. (B): X-ray emission spectra as function of the delay between excitation and probe provide snapshots of the electronic structure during ultrafast relaxation.

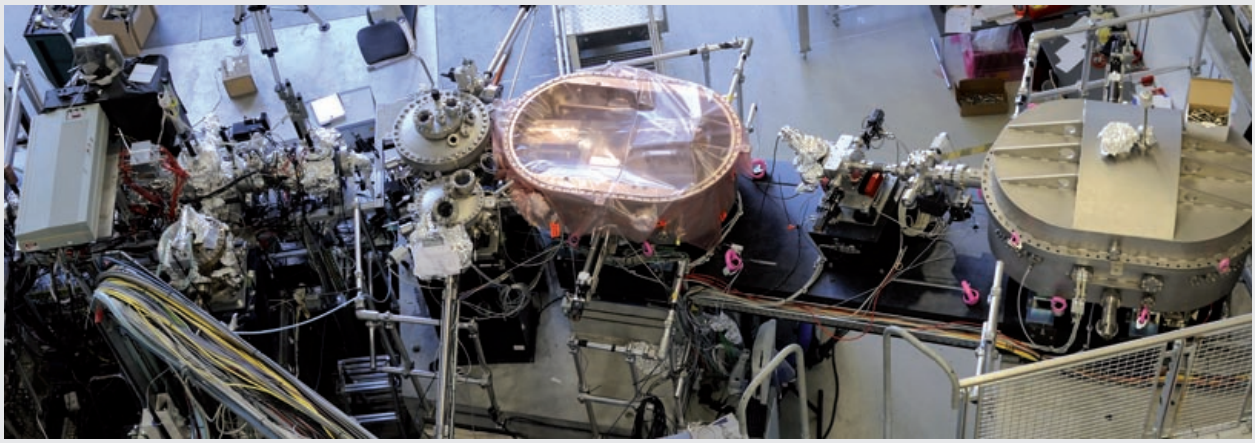


Figure 5: VUV Raman spectrometer at FLASH beamline PG1.

CFEL EVENTS

September 29th 2009 Laying of the Foundation Stone
A first milestone in the construction of the CFEL building was achieved with the laying of the foundation stone. Despite the rainy weather approximately 150 people attended the laying of the foundation stone. Dr. Herlind Gundelach, Hamburg's Senator for Science and Research opened the ceremony with a short greeting. Prof. Dr.-Ing. Hans Siegfried Stiehl, Vice President of the University of Hamburg and Christian Scherf, DESY Director of Administration gave short addresses underlining the importance of CFEL for their institutions. Both speakers acknowledged the city of Hamburg for supporting this new building that enables this interdisciplinary institution to attract the best scientists from all over the world. Prof. Dr. Joachim H. Ullrich, head of the CFEL management board, head of the MPG-ASG, and director at the MPI for Nuclear Physics in Heidelberg addressed the audience on behalf of the Max Planck Society and CFEL, agreeing with the previous speakers about the importance of CFEL for the three institutions and the city of Hamburg.

The four speakers placed the traditional items into a copper time capsule: a local newspaper of the day, current coins, one set of the architects' drawings of the CFEL building, several scientific papers published by the CFEL group leaders, and two special items related to the CFEL research - the prototype of a pnCCD detector chip for fast X-ray detection and the CFEL logo drilled in a silicon wafer by a focused ion beam. The copper capsule was then sealed and buried in the central ground plate of the building, according to tradition. Finally, the ceremony ended with a small reception in the adjoining PETRA III hall.

June 8th-11th 2010 Coherence: International Workshop on Phase Retrieval and Coherent Scattering
Coherence 2010 took place in Rostock-Warnemünde in Germany, mainly organized by CFEL scientists and staff from the Coherent Imaging Division together with scientists from DESY, XFEL, and TU Berlin. Coherence 2010 was the fifth international conference in a series dedicated to the understanding of phase retrieval and coherent scattering. With over 130 researchers it offered great talks and an exciting poster session. The participation of lots of young people clearly showed that the research field is expanding significantly.

Juli 20th 2010 CFEL Symposium and Topping out Ceremony
The Center for Free-Electron Laser Science celebrated the topping out of the future CFEL home together with the three partner institutions and the Free and Hanseatic City of Hamburg (FHH). On this occasion CFEL held a scientific symposium in the morning followed by the topping out in the early afternoon.

Joachim Ullrich – head of the CFEL management board, head of the MPG-ASG, and director at the MPI for Nuclear Physics in Heidelberg – welcomed the audience and honored Prof. Dr. Jochen Schneider as the first CFEL Distinguished Fellow

Laying of the foundation stone for the CFEL building. (Right picture: from left to right C. Scherf (DESY), H. Gundelach (FHH), H. S. Stiehl (UHH), and J. Ullrich (MPG, CFEL). Left picture: in action.)

Topping-out (from left): Prof. Dr.-Ing. H. Siegfried Stiehl (UHH), Prof. Dr. Helmut Dosch (DESY), Dr. Herlind Gundelach (FHH), Prof. Dr. Martin Stratmann (MPG), Prof. Dr. Joachim H. Ullrich (MPG, CFEL).

at the beginning of the symposium. The scientific program included four invited talks presented by: Joachim Stöhr, LCLS Director at the SLAC National Accelerator Laboratory, *"Ten Years After: LCLS, From Vision to Reality"*; Henry Chapman, Director of the Coherent Imaging Division at CFEL, *"Coherent X-ray diffraction at X-ray Free-Electron Lasers"*; Tsumoru Shintake, Accelerator Group Director at the Institute of Physical and Chemical Research (RIKEN) in Japan, *"Coherent illumination of Angstrom-scale matter with high/low fast/slow photon/lepton waves"*; Andrea Cavalleri, Director of the Condensed Matter Dynamics Division at CFEL, *"Ultrafast X-ray science in complex solids"*.

The topping out ceremony started with raising the flags of Germany, the Free and Hanseatic City of Hamburg, and the three CFEL partner organizations - the University of Hamburg, Deutsches Elektronen-Synchrotron, and the Max Planck Society - over the construction site in early afternoon's sunny blue sky. In her address Science and Research Senator of Hamburg Dr. H. Gundelach expressed her pride and her thankfulness to all those committing themselves to the idea of an interdisciplinary research center for Free-Electron Laser Science in Hamburg. The Vice-President of the University of Hamburg, Prof. Dr.-Ing. Hans Siegfried Stiehl, pointed out that the unique cooperation between DESY, MPG and the University of Hamburg has already achieved excellent networking among the three organizations in the field of FEL research. Prof. Dr. Martin Stratmann, Vice President of the Max Planck Society, wished all CFEL scientists power, endurance, intuition and enthusiasm to explore their fascinating new research field. Prof. Dr. Helmut Dosch, Chairman of the DESY Board of Directors, expressed his conviction that CFEL will set new standards in research and dramatically expand the borders in bio and nano science. In the final address Prof. Dr. Joachim H. Ullrich thanked the city of Hamburg for its strong commitment and the architects for their excellent design.

The ceremony ended traditionally with the topping out toast by the construction foreman, the raising of the topping out wreath and finally the topping out feast on the lawn right next to the FLASH hall.

PUBLICATIONS

M. M. Seibert, T. Ekeberg, F. R. N. C. Maia, M. Svenda, J. Andreasson, O. Jönsson, D. Odic, B. Iwan, A. Rocker, D. Westphal, M. Hantke, D. P. DePonte, A. Barty, J. Schulz, L. Gumprecht, N. Coppola, A. Aquila, M. Liang, T. A. White, A. Martin, C. Caleman, S. Stern, C. Abergel, V. Seltzer, J.-M. Claverie, C. Bostedt, J. D. Bozek, S. Boutet, A. A. Miahnahri, M. Messerschmidt, J. Krzywinski, G. Williams, K. O. Hodgson, M. J. Bogan, C. Y. Hampton, R. G. Sierra, D. Starodub, I. Andersson, S. Bajt, M. Barthelmess, J. C. H. Spence, P. Fromme, U. Weierstall, R. Kirian, M. Hunter, R. B. Doak, S. Marchesini, S. P. Hau-Riege, M. Frank, R. L. Shoeman, L. Lomb, S. W. Epp, R. Hartmann, D. Rolles, A. Rudenko, C. Schmidt, L. Foucar, N. Kimmel, P. Holl, B. Rudek, B. Erk, A. Hömke, C. Reich, D. Pietschner, G. Weidenspointner, L. Strüder, G. Hauser, H. Gorke, J. Ullrich, I. Schlichting, S. Herrmann, G. Schaller, F. Schopper, H. Soltau, K.-U. Kühnel, R. Andritschke, C.-D. Schröter, F. Krasniqi, M. Bott, S. Schorb, D. Rupp, M. Adolph, T. Gorkhover, H. Hirsemann, G. Potdevin, H. Graafsma, B. Nilsson, H. N. Chapman, J. Hajdu,
"Single mimivirus particles intercepted and imaged with an X-ray laser",
Nature (2010) in press.

H. N. Chapman, P. Fromme, A. Barty, T. A. White, R. A. Kirian, A. Aquila, M. S. Hunter, J. Schulz, D. P. DePonte, U. Weierstall, R. B. Doak, F. R. N. C. Maia, A. V. Martin, I. Schlichting, L. Lomb, N. Coppola, R. L. Shoeman, S. W. Epp, R. Hartmann, D. Rolles, A. Rudenko, L. Foucar, N. Kimmel, G. Weidenspointner, P. Holl, M. Liang, M. Barthelmess, C. Caleman, S. Boutet, M. J. Bogan, J. Kryzwinski, C. Bostedt, S. Bajt, L. Gumprecht, B. Rudek, B. Erk, C. Schmidt, A. Hömke, C. Reich, D. Pietschner, L. Strüder, G. Hauser, H. Gorke, J. Ullrich, S. Herrmann, G. Schaller, F. Schopper, H. Soltau, K.-U. Kühnel, M. Messerschmidt, J. Bozek, S. P. Hau-Riege, M. Frank, C. Y. Hampton, R. G. Sierra, D. Starodub, G. J. Williams, J. Hajdu, N. Timneanu, M. M. Seibert, J. Andreasson, A. Rocker, O. Jönsson, M. Svenda, S. Stern, K. Nass, R. Andritschke, C.-D. Schröter, F. Krasniqi, M. Bott, K. E. Schmidt, X. Wang, I. Grotjohann, J. M. Holton, T. R. M. Barends, R. Neutze, S. Marchesini, R. Fromme, S. Schorb, D. Rupp, M. Adolph, T. Gorkhover, I. Andersson, H. Hirsemann, C. Potdevin, H. Graafsma, B. Nilsson, J. C. H. Spence,
"Femtosecond X-ray protein nanocrystallography",
Nature (2010) in press.

S. Pabst, L. Greenman, P. J. Ho, D. A. Mazziotti, R. Santra,
"Decoherence in attosecond photoionization",
Phys. Rev. Lett. (2010) in press.

O. Vendrell and H.-D. Meyer,
"Multilayer multiconfiguration time-dependent Hartree method: Implementation and applications to a Henon–Heiles Hamiltonian and to pyrazine",
J. Chem. Phys. (2010) in press.

J. Andreasson, B. Iwan, A. Andrejczuk, E. Abreu, M. Bergh, C. Caleman, A. J. Nelson, S. Bajt, J. Chalupsky, H. N. Chapman, R. R. Fäustlin, V. Hajkova, P. A. Heimann, B. Hjörvarsson, L. Juha, D. Klinger, J. Krzywinski, B. Nagler, G. K. Pálsson, W. Singer, M. M. Seibert, R. Sobierajski, S. Toleikis, T. Tschentscher, S. M. Vinko, R. W. Lee, J. Hajdu, N. Timneanu,
"Saturated ablation in metal hydrides and acceleration of protons and deuterons to keV energies with a soft-X-ray laser",
Phys. Rev. E (2010) in press.

H. Ichikawa, S. Nozawa, T. Sato, A. Tomita, K. Ichiyanagi, M. Chollet, L. Guerin, N. Dean, A. Cavalleri, S. Adachi, T. Arima, H. Sawa, Y. Ogimoto, M. Nakamura, R. Tamaki, K. Miyano, S. Koshihara,
"Transient photoinduced 'hidden' phase in a manganite",
Nat. Mater. (2010) in press.

D. Fausti, R. I. Tobey, N. Dean, S. Kaiser, A. Dienst, M. Hoffman, S. Pyon, T. Takayama, H. Takagi, A. Cavalleri,
"Light-induced superconductivity in a stripe-ordered cuprate",
Science (2010) in press.

D. van der Spoel, E. G. Marklund, D. S. D. Larsson, C. Caleman,
"Proteins, lipids, and water in the gas phase",
Macromol. Biosci. (2010) in press.

B. Ziaja, A. V. Martin, F. Wang, H. N. Chapman, E. Weckert,
"Theoretical estimation for correlations of diffraction patterns from objects differently oriented in space",
Ultramicroscopy (2010) in press.

N. Dean, J. C. Petersen, D. Fausti, R. I. Tobey, S. Kaiser, L. V. Gasparov, H. Berger, A. Cavalleri,
"Polaronic conductivity in the photoinduced phase of 1*T*-TaS_2",
Phys. Rev. Lett. (2010) in press.

A. Zarrine-Afsar, C. Müller, F. O. Talbot, R. J. D. Miller,
"Self-localizing stabilized mega-pixel picoliter arrays with size-exclusion sorting capabilities",
Anal. Chem. (2010) in press.

F. Filsinger, G. Meijer, H. Stapelfeldt, H. N. Chapman, J. Küpper,
"State- and conformer-selected beams of aligned and oriented molecules for ultrafast diffraction studies",
Phys. Chem. Chem. Phys. (2010) in press.

C. Caleman, G. Huldt, F. R. N. C. Maia, C. Ortiz, F. G. Parak, J. Hajdu, D. van der Spoel, H. N. Chapman, N. Timneanu,
"On the feasibility of nanocrystal imaging using intense and ultrashort X-ray pulses",
ACS Nano (2010) in press.

S. Wall, D. Brida, S. R. Clark, H. P. Ehrke, D. Jaksch, A. Ardavan, S. Bonora, H. Uemura, Y. Takahashi, T. Hasegawa, H. Okamoto, G. Cerullo, A. Cavalleri,
"Quantum interference between charge excitation paths in a solid-state Mott insulator",
Nat. Phys. (2010) in press.

S.-K. Son, L. Young, R. Santra,
"Impact of hollow-atom formation on coherent X-ray scattering at high intensity",
Phys. Rev. A (2010) in press.

W. Quevedo, I. Rajkovic, G. Busse, J. Hallmann, R. More, M. Petri, F. Krasniqi, A. Rudenko, T. Tschentscher, A. Föhlisch, A. Pietsch, M. Beye, N. Stojanovic, S. Düsterer, R. Treusch, M. Tolkien, K. Mann, C. Peth, S. Techert,
"Time dynamics studies of periodic lattices under FEL radiation",
Phys. Rev. Lett. (2010) in press.

B. Langer, K. Kiyoshi, O. M. Al-Dossary, U. Becker,
"Photoinduced localization and decoherence in inversion symmetric molecules",
J. Electron Spec. (2010) in press.

V. Averbukh, P. V. Demekhin, P. Kolorenč, S. Scheit, S. D. Stoychev, A. I. Kuleff, Y.-C. Chiang, K. Gokhberg, S. Kopelke, N. Sisourat, L. S. Cederbaum,
"Interatomic electronic decay processes in singly and multiply ionized clusters",
J. Electron Spec. (2010) in press.

R. Santra, V. S. Yakovlev, T. Pfeifer, Z.-H. Loh,
"Theory of attosecond transient absorption spectroscopy of strong-field-generated ions",
Phys. Rev. A, (2010) in press.

J. R. Schneider,
"Photon science at accelerator-based light sources",
Rev. Accel. Sci. Technol. **3** (2010) 13.

Y. H. Jiang, A. Rudenko, O. Herrwerth, L. Foucar, M. Kurka, K. U. Kühnel, M. Lezius, M. F. Kling, J. van Tilborg, A. Belkacem, K. Ueda, S. Düsterer, R. Treusch, C. D. Schröter, R. Moshammer, J. Ullrich,
"Ultrafast XUV induced isomerization of acetylene cations",
Phys. Rev. Lett. **105** (2010) 263002.

L. Lammich, C. Domesle, B. Jordon-Thaden, M. Förstel, T. Arion. T. Lischke, O. Heber, S. Klumpp, M. Martins, N. Guerassimova, R. Treusch, J. Ullrich, U. Hergenhahn, H. B. Petersen, A. Wolf,
"Fragmentation pathways of $H^+(H_2O)_2$ after XUV photoionization",
Phys. Rev. Lett. **105** (2010) 253003.

M. Eichberger, H. Schäfer, M. Krumova, M. Beyer, J. Demsar, H. Berger, G. Moriena, G. Sciaini, R. J. D. Miller,
"Snapshots of cooperative atomic motions in the optical suppression of charge density waves",
Nature **468** (2010) 799.

J. R. Schneider,
"FLASH: the king of VUV and soft X-rays",
CERN Courier **50** (2010) 21.

H. N. Chapman and K. A. Nugent,
"Coherent lensless X-ray imaging",
Nat. Photonics **4** (2010) 883.

S. Hellmann, M. Beye, C. Sohrt, T. Rohwer, F. Sorgenfrei, H. Redlin, M. Kalläne, M. Marczynski-Bühlow, F. Hennies, M. Bauer, A. Föhlisch, L. Kipp, W. Wurth, K. Rossnagel,
"Ultrafast melting of a charge-density wave in the Mott insulator 1*T*-TaS_2",
Phys. Rev. Lett. **105** (2010) 187401.

I. Dumitriu, R. C. Bilodeau, T. W. Gorczyca, C. W. Walter, N. D. Gibson, Z. D. Pešic, D. Rolles, N. Berrah,
"Inner-shell photodetachment from Ru^-",
Phys. Rev. A **82** (2010) 013401.

Y. H. Jiang, T. Pfeifer, A. Rudenko, O. Herrwerth, L. Foucar, M. Kurka, K. U. Kühnel, M. Lezius, M. F. Kling, X. Liu, K. Ueda, S. Düsterer, R. Treusch, C. D. Schröter, R. Moshammer, J. Ullrich,
"Temporal coherence effects in multiple ionization of N_2 via XUV pump-probe autocorrelation",
Phys. Rev. A **82** (2010) 041403(R).

T. Pfeifer, Y. Jiang, S. Düsterer, R. Moshammer, J. Ullrich,
"Partial-coherence method to model experimental FEL pulse statistics",
Opt. Lett. **35** (2010) 3441.

S. Korica, A. Reinköster, M. Braune, J. Viefhaus, D. Rolles, B. Langer, G. Fronzoni, D. Toffoli, M. Stener, P. Decleva, O. M. Al-Dossary, U. Becker,
"Partial photoionization cross sections of $C_{60}$and C_{70}: a gas versus adsorbed phase comparison",
Surf. Sci. **604** (2010) 1940.

H. N. Chapman,
"A new phase for X-ray imaging",
Nature **467** (2010) 409.

S. Toleikis, T. Bornath, T. Döppner, S. Düsterer, R. R. Fäustlin, E. Förster, C. Fortmann, S. H. Glenzer, S. Göde, G. Gregori, R. Irsig, T. Laarmann, H. J. Lee, B. Li, K.-H. Meiwes-Broer, J. Mithen, B. Nagler, A. Przystawik, P. Radcliffe, H. Redlin, R. Redmer, H. Reinholz, G. Röpke, F. Tavella, R. Thiele, J. Tiggesbäumker, I. Uschmann, S. M. Vinko, T. Whitcher, U. Zastrau, B. Ziaja, T. Tschentscher,
"Probing near-solid density plasmas using soft X-ray scattering",
J. Phys. B **43** (2010) 194017.

M. M. Seibert, S. Boutet, M. Svenda, T. Ekeberg, F. R. N. C. Maia, M. J. Bogan, N. Tîmneanu, A. Barty, S. Hau-Riege, C. Caleman, M. Frank, H. Benner, J. Y. Lee, S. Marchesini, J. W. Shaevitz, D. A. Fletcher, S. Bajt, I. Andersson, H. N. Chapman, J. Hajdu,
"Femtosecond diffractive imaging of biological cells",
J. Phys. B **43** (2010) 194015.

A. Barty,
"Time-resolved imaging using X-ray FELs",
J. Phys. B **43** (2010) 194014.

M. J. Bogan, S. Boutet, A. Barty, W. H. Benner, M. Frank, L. Lomb, R. Shoeman, D. Starodub, M. M. Seibert, S. P. Hau-Riege, B. Woods, P. Decorwin-Martin, S. Bajt, J. Schulz, U. Rohner, B. Iwan, N. Timneanu, S. Marchesini, I. Schlichting, J. Hajdu, H. N. Chapman,
"Single-shot femtosecond X-ray diffraction from randomly oriented ellipsoidal nanoparticles",
Phys. Rev. ST Accel. Beams **13** (2010) 094701.

U. Saalmann,
"Cluster nanoplasmas in strong FLASH pulses: formation, excitation and relaxation",
J. Phys. B **43** (2010) 194012.

M. Drescher, U. Frühling, M. Krikunova, T. Maltezopoulos, M. Wieland,
"Time-diagnostics for improved dynamics experiments at XUV FELs",
J. Phys. B **43** (2010) 194010.

J. Hallmann, S. Grübel, I. Rajkovic, W. Quevedo, G. Busse, M. Scholz, R. More, M. Petri, S. Techert,
"First steps towards probing chemical systems and dynamics with FEL radiation - case studies at the FLASH facility",
J. Phys. B **43** (2010) 194009.

S. W. Epp, J. R. Crespo López-Urrutia, M. C. Simon, T. Baumann, G. Brenner, R. Ginzel, N. Guerassimova, V. Mäckel, P. H. Mokler, B. L. Schmitt, H. Tawara, J. Ullrich,
"X-ray laser spectroscopy of highly charged ions at FLASH",
J. Phys. B **43** (2010) 194008.

A. Wolf, H. B. Pedersen, L. Lammich, B. Jordon-Thaden, S. Altevogt, C. Domesle, U. Hergenhahn, M. Förstel, O. Heber,
"Soft-X-ray fragmentation studies of molecular ions",
J. Phys. B **43** (2010) 194007.

A. Rudenko, Y. H. Jiang, M. Kurka, K. U. Kühnel, L. Foucar, O. Herrwerth, M. Lezius, M. F. Kling, C. D. Schröter, R. Moshammer, J. Ullrich,
"Exploring few-photon, few-electron reactions at FLASH: from ion yield and momentum measurements to time-resolved and kinematically complete experiments",
J. Phys. B **43** (2010) 194004.

J. R. Schneider,
"FLASH – from accelerator test facility to the first single-pass soft X-ray FEL",
J. Phys. B **43** (2010) 194001.

H. Chapman, J. Ullrich, J. M. Rost,
"Intense X-ray science: the first 5 years of FLASH",
J. Phys. B **43** (2010) 190201.

M. Beye, F. Sorgenfrei, W. F. Schlotter, W. Wurth, A. Föhlisch,
"The liquid-liquid phase transition in silicon revealed by snapshots of valence electrons",
Proc. Natl. Acad. Sci. USA **107** (2010) 16772.

H. B. Pedersen, L. Lammich, C. Domesle, B. Jordon-Thaden, O. Heber, J. Ullrich, R. Treusch, N. Guerassimova, A. Wolf,
"Experimental investigation of dissociation pathways of cooled HeH^+ following valence electron excitation at 32 nm by intense FEL radiation",
Phys. Rev. A **82** (2010) 023415.

C. Bostedt, H. Thomas, M. Hoener, T. Möller, U. Saalmann, I. Georgescu, C. Gnodtke, J.-M. Rost,
"Fast electrons from multi-electron dynamics in xenon clusters induced by inner-shell ionization",
New J. Phys. **12** (2010) 083004.

M. Kurka, J. Feist, D. A. Horner, A. Rudenko, Y. H. Jiang, K. U. Kühnel, L. Foucar, T. N. Rescigno, C. W. McCurdy, R. Pazourek, S. Nagele, M. Schulz, O. Herrwerth, M. Lezius, M. F. Kling, M. Schöffler, A. Belkacem, S. Düsterer, R. Treusch, B. I. Schneider, L. A. Collins, J. Burgdörfer, C. D. Schröter, R. Moshammer, J. Ullrich,
"Differential cross sections for non-sequential double ionization of He by 52 eV photons from the FEL in Hamburg, FLASH",
New J. Phys. **12** (2010) 073035.

S. P. Hau-Riege, R. M. Bionta, D. D. Ryutov, R. A. London, E. Ables, K. I. Kishiyama, S. Shen, M. A. McKernan, D. H. McMahon, M. Messerschmidt, J. Krzywinski, P. Stefan, J. Turner, B. Ziaja,
"Near-UV luminescence of N_2 irradiated by short X-ray pulses",
Phys. Rev. Lett. **105** (2010) 043003.

A. Rusydi, W. Ku, B. Schulz, R. Rauer, I. Mahns, D. Qi, X. Gao, A. T. S. Wee, P. Abbamonte, H. Eisaki, Y. Fujimaki, S. Uchida, M. Rübhausen,
"Experimental observation of the crystallization of a paired holon state",
Phys. Rev. Lett. **105** (2010) 026402.

N. Berrah, J. Bozek, J. T. Costello, S. Düsterer, L. Fang, J. Feldhaus, H. Fukuzawa, M. Hoener, Y. H. Jiang, P. Johnsson, E. T. Kennedy, M. Meyer, R. Moshammer, P. Radcliffe, M. Richter, A. Rouzée, A. Rudenko, A. A. Sorokin, K. Tiedtke, K. Ueda, J. Ullrich, M. J. J. Vrakking,
"Non-linear processes in the interaction of atoms and molecules with intense EUV and X-ray fields from SASE FELs",
J. Modern Opt. **57** (2010) 1015.

M. Hoener, L. Fang, O. Kornilov, O. Gessner, S. T. Pratt, M. Gühr, E. P. Kanter, C. Blaga, C. Bostedt, J. D. Bozek, P. H. Bucksbaum, C. Buth, M. Chen, R. Coffee, J. Cryan, L. DiMauro, M. Glownia, E. Hosler, E. Kukk, S. R. Leone, B. McFarland, M. Messerschmidt, B. Murphy, V. Petrovic, D. Rolles, N. Berrah,
"Ultraintense X-ray induced ionization, dissociation, and frustrated absorption in molecular nitrogen",
Phys. Rev. Lett. **104** (2010) 253002.

L. Holmegaard, J. L. Hansen, L. Kalhøj, S. L. Kragh, H. Stapelfeldt, F. Filsinger, J. Küpper, G. Meijer, D. Dimitrovski, M. Abu-samha, C. P. J. Martiny, L. B. Madsen,
"Photoelectron angular distributions from strong-field ionization of oriented molecules",
Nat. Phys. **6** (2010) 428.

A. Castoldi, C. Guazzoni, R. Hartmann, D. Mezza, L. Strüder, F. Tassan Garofolo,
"2-D response mapping of multi-linear silicon drift detectors",
Nucl. Instrum. Meth. A **624** (2010) 255.

V. Averbukh, U. Saalmann, J. M. Rost,
"Suppression of exponential electronic decay in a charged environment",
Phys. Rev. Lett. **104** (2010) 233002.

S. M. Vinko, U. Zastrau, S. Mazevet, J. Andreasson, S. Bajt, T. Burian, J. Chalupsky, H. N. Chapman, J. Cihelka, D. Doria, T. Döppner, S. Düsterer, T. Dzelzainis, R. R. Fäustlin, C. Fortmann, E. Förster, E. Galtier, S. H. Glenzer, S. Göde, G. Gregori, J. Hajdu, V. Hajkova, P. A. Heimann, R. Irsig, L. Juha, M. Jurek, J. Krzywinski, T. Laarmann, H. J. Lee, R. W. Lee, B. Li, K.-H. Meiwes-Broer, J. P. Mithen, B. Nagler, A. J. Nelson, A. Przystawik, R. Redmer, D. Riley, F. Rosmej, R. Sobierajski, F. Tavella, R. Thiele, J. Tiggesbäumker, S. Toleikis, T. Tschentscher, L. Vysin, T. J. Whitcher, S. White, J. S. Wark,
"Electronic structure of an XUV photogenerated solid-density aluminum plasma",
Phys. Rev. Lett. **104** (2010) 225001.

N. D. Loh, M. J. Bogan, V. Elser, A. Barty, S. Boutet, S. Bajt, J. Hajdu, T. Ekeberg, F. R. N. C. Maia, J. Schulz, M. M. Seibert, B. Iwan, N. Timneanu, S. Marchesini, I. Schlichting, R. L. Shoeman, L. Lomb, M. Frank, M. Liang, H. N. Chapman,
"Cryptotomography: reconstructing 3D Fourier intensities from randomly oriented single-shot diffraction patterns",
Phys. Rev. Lett. **104** (2010) 225501.

Z. D. Pešic, D. Rolles, I. Dumitriu, N. Berrah,
"Fragmentation dynamics of gas-phase furan following *K*-shell ionization",
Phys. Rev. A **82** (2010) 013401.

K. Franjic and R. J. D. Miller,
"Vibrationally excited ultrafast thermodynamic phase transitions at the water/air interface",
Phys. Chem. Chem. Phys. **12** (2010) 5225.

A. Yamada, H. Fukuzawa, K. Motomura, X.-J. Liu, L. Foucar, M. Kurka, M. Okunishi, K. Ueda, N. Saito, H. Iwayama, K. Nagaya, A. Sugishima, H. Murakami, M. Yao, A. Rudenko, K. U. Kühnel, J. Ullrich, R. Feifel, A. Czasch, R. Dörner, M. Nagasono, A. Higashiya, M. Yabashi, T. Ishikawa, H. Ohashi, H. Kimura, T. Togashi,
"Ion-ion coincidence studies on multiple ionizations of N_2 and O_2 molecules irradiated by EUV FEL pulses",
J. Chem. Phys. **132** (2010) 204305.

Y. H. Jiang, A. Rudenko, J. F. Pérez-Torres, O. Herrwerth, L. Foucar, M. Kurka, K. U. Kühnel, M. Toppin, E. Plésiat, F. Morales, F. Martín, M. Lezius, M. F. Kling, T. Jahnke, R. Dörner, J. L. Sanz-Vicario, J. van Tilborg, A. Belkacem, M. Schulz, K. Ueda, T. J. M. Zouros, S. Düsterer, R. Treusch, C. D. Schröter, R. Moshammer, J. Ullrich,
"Investigating two-photon double ionization of D_2 by XUV-Pump-XUV-Probe experiments",
Phys. Rev. A **81** (2010) 051402(R).

N. Kimmel, R. Andritschke, R. Hartmann, P. Holl, N. Meidinger, R. Richter, L. Strüder,
"Experimental and theoretical study of the signal electron motion in fully depleted silicon",
Nucl. Instrum. Meth. A **624** (2010) 334.

I. Dumitriu, R. C. Bilodeau, T. W. Gorczyca, C. W. Walter, N. D. Gibson, A. Aguilar, Z. D. Pešic, D. Rolles, N. Berrah,
"Inner-shell photodetachment from Fe^-",
Phys. Rev. A **81** (2010) 053404.

D. K. Saldin, H. C. Poon, V. L. Shneerson, M. Howells, H. N. Chapman, R. A. Kirian, K. E. Schmidt, J. C. H. Spence,
"Beyond SAXS: exploiting angular correlations",
Phys. Rev. B **81** (2010) 174105.

Y. Liu, D. Ye, J. Liu, A. Rudenko, S. Tschuch, M. Dürr, M. Siegel, U. Morgner, Q. Gong, R. Moshammer, J. Ullrich,
"Multiphoton double ionization of Ar and Ne close to threshold",
Phys. Rev. Lett. **104** (2010) 173002.

F. Sorgenfrei, W. F. Schlotter, T. Beeck, M. Nagasono, S. Gieschen, H. Meyer, A. Föhlisch, M. Beye, W. Wurth,
"The XUV split and femtosecond delay unit at the plane grating monochromator beamline PG2 at FLASH",
Rev. Sci. Instrum. **81** (2010) 043107.

D. M. Schlosser, P. Lechner, G. Lutz, A. Nicolae, H. Soltau, L. Strüder, R. Eckhardt, K. Hermenau, G. Schaller, F. Schopper, O. Jaritschin, A. Liebel, C. Fiorini, A. Longoni,
"Expanding the detection efficiency of silicon drift detectors",
Nucl. Instrum. Meth. A **624** (2010) 270.

I. Rajkovic, J. Hallmann, S. Grübel, R. More, W. Quevedo, M. Petri, S. Techert,
"Development of a multipurpose vacuum chamber for serial optical and diffraction experiments with FEL radiation",
Rev. Sci. Instrum. **81** (2010) 045105.

I. Rajkovic, J. Hallmann, S. Grübel, R. More, W. Quevedo, M. Petri, S. Techert,
"Development of a multipurpose vacuum chamber for serial optical and diffraction experiments with FEL radiation",
Virt. J. Ultrafast Sci. **9**(5) (2010).

G. Schächner, R. Andritschke, O. Hälker, S. Herrmann, N. Kimmel, N. Meidinger, L. Strüder,
"First qualification and selection of the eROSITA pnCCDs",
Nucl. Instrum. Meth. A **624** (2010) 330.

D. Rolles, G. Prümper, H. Fukuzawa, X.-J. Liu, J. Harries, K. Ueda, Z. D. Pešic, I. Dumitriu, N. Berrah,
"Molecular-frame angular distribution of normal and resonant Auger electrons",
J. Phys. Conf. Ser. **212** (2010) 012009.

M. Beye, F. Hennies, M. Deppe, E. Suljoti, M. Nagasono, W. Wurth, A. Föhlisch,
"Measurement of the predicted asymmetric closing behavior of the band gap of silicon using X-ray absorption and emission spectroscopy",
New J. Phys. **12** (2010) 043011.

D. K. Saldin, V. L. Shneerson, M. R. Howells, S. Marchesini, H. N. Chapman, M. Bogan, D. Shapiro, R. A. Kirian, U. Weierstall, K. E. Schmidt, J. C. H. Spence,
"Structure of a single particle from scattering by many particles randomly oriented about an axis: towards structure solution without crystallization?",
New J. Phys. **12** (2010) 035014.

I. Rajkovic, G. Busse, J. Hallmann, R. Moré, M. Petri, W. Quevedo, F. Krasniqi, A. Rudenko, T. Tschentscher, N. Stojanovic, S. Düsterer, R. Treusch, M. Tolkiehn, S. Techert,
"Diffraction properties of periodic lattices under FEL radiation",
Phys. Rev. Lett. **104** (2010) 125503.

R. R. Fäustlin, T. Bornath, T. Döppner, S. Düsterer, E. Förster, C. Fortmann, S. H. Glenzer, S. Göde, G. Gregori, R. Irsig, T. Laarmann, H. J. Lee, B. Li, K.-H. Meiwes-Broer, J. Mithen, B. Nagler, A. Przystawik, H. Redlin, R. Redmer, H. Reinholz, G. Röpke, F. Tavella, R. Thiele, J. Tiggesbäumker, S. Toleikis, I. Uschmann, S. M. Vinko, T. Whitcher, U. Zastrau, B. Ziaja, T. Tschentscher,
"Observation of ultrafast nonequilibrium collective dynamics in warm dense hydrogen",
Phys. Rev. Lett. **104** (2010) 125002.

G. Lutz, P. Lechner, M. Porro, L. Strüder, G. de Vita,
"DePFET sensor with intrinsic signal compression developed for the use at the XFEL FEL source",
Nucl. Instrum. Meth. A **624** (2010) 528.

F. Krasniqi, B. Najjari, L. Strüder, D. Rolles, A. Voitkiv, J. Ullrich,
"Imaging molecules from within: ultrafast angström-scale structure determination of molecules via photoelectron holography using FELs",
Phys. Rev. A **81** (2010) 033411.

J. Hallmann, S. Techert,
"Photoluminescence properties of a molecular organic switching system",
J. Phys. Chem. Lett. **1** (2010) 959.

R. A. Kirian, X. Wang, U. Weierstall, K. E. Schmidt, J. C. H. Spence, M. Hunter, P. Fromme, T. White, H. N. Chapman, J. Holton,
"Femtosecond protein nanocrystallography-data analysis methods",
Opt. Express **18** (2010) 5713.

M. Porro, L. Andricek, L. Bombelli, G. de Vita, C. Fiorini, P. Fischer, K. Hansen, P. Lechner, G. Lutz, L. Strüder, G. Weidenspointner,
"Expected performance of the DEPFET sensor with signal compression: a large format X-ray imager with mega-frame readout capability for the European XFEL",
Nucl. Instrum. Meth. A **624** (2010) 509.

C. Manzoni, M. Först, H. Ehrke, A. Cavalleri,
"Single-shot detection and direct control of carrier phase drift of midinfrared pulses",
Opt. Lett. **35** (2010) 757.

R. J. D. Miller, R. Ernstorfer, M. Harb, M. Gao, C. T. Hebeisen, H. Jean-Ruel, C. Lu, G. Moriena, G. Sciaini,
"Making the molecular movie: first frames",
Acta Cryst. A **66** (2010) 137.

Y. H. Jiang, A. Rudenko, E. Plésiat, L. Foucar, M. Kurka, K. U. Kühnel, T. Ergler, J. F. Pérez-Torres, F. Martín, O. Herrwerth, M. Lezius, M. F. Kling, J. Titze, T. Jahnke, R. Dörner, J. L. Sanz-Vicario, M. Schöffler, J. van Tilborg, A. Belkacem, K. Ueda, T. J. M. Zouros, S. Düsterer, R. Treusch, C. D. Schröter, R. Moshammer, J. Ullrich,
"Tracing direct and sequential two-photon double ionization of D_2 in femtosecond XUV laser pulses",
Phys. Rev. A **81** (2010) 021401(R).

S. P. Hau-Riege, S. Boutet, A. Barty, S. Bajt, M. J. Bogan, M. Frank, J. Andreasson, B. Iwan, M. M. Seibert, J. Hajdu, A. Sakdinawat, J. Schulz, R. Treusch, H. N. Chapman,
"Sacrificial tamper slows down sample explosion in FLASH diffraction experiments",
Phys. Rev. Lett. **104** (2010) 064801.

M. Hoener, D. Rolles, A. Aguilar, R. C. Bilodeau, D. Esteves, P. Olalde Velasco, Z. D. Pešic, E. Red, N. Berrah,
"Site-selective ionization and relaxation dynamics in heterogeneous nanosystems",
Phys. Rev. A **81** (2010) 021201(R).

M. Mucke, M. Braune, S. Barth, M. Förstel, T. Lischke, V. Ulrich, T. Arion, U. Becker, A. Bradshaw, U. Hergenhahn,
"A hitherto unrecognized source of low-energy electrons in water",
Nat. Phys. **6** (2010) 143.

W. F. Schlotter, F. Sorgenfrei, T. Beeck, M. Beye, S. Gieschen, H. Meyer, M. Nagasono, A. Föhlisch, W. Wurth,
"Longitudinal coherence measurements of an XUV FEL",
Opt. Lett. **35** (2010) 372.

M. J. Bogan, S. Boutet, H. N. Chapman, S. Marchesini, A. Barty, W. H. Benner, U. Rohner, M. Frank, S. P. Hau-Riege, S. Bajt, B. Woods, M. M. Seibert, B. Iwan, N. Timneanu, J. Hajdu, J. Schulz,
"Aerosol imaging with a Soft X-Ray FEL",
Aerosol Sci. Tech. **44** (2010) i-vi.

F. Cilento, C. Giannetti, G. Ferrini, S. Dal Conte, T. Sala, G. Coslovich, M. Rini, A. Cavalleri, F. Parmigiani,
"Ultrafast insulator-to-metal phase transition as a switch to measure the spectrogram of a supercontinuum light pulse",
Appl. Phys. Lett. **96** (2010) 021102.

L. Strüder, S. Epp, D. Rolles, R. Hartmann, P. Holl, G. Lutz, H. Soltau, R. Eckart, C. Reich, K. Heinzinger, C. Thamm, A. Rudenko, F. Krasniqi, K.-U. Kühnel, C. Bauer, C. D. Schröter, R. Moshammer, S. Techert, D. Miessner, M. Porro, O. Hälker, N. Meidinger, N. Kimmel, R. Andritschke, F. Schopper, G. Weidenspointner, A. Ziegler, D. Pietschner, S. Herrmann, U. Pietsch, A. Walenta, W. Leitenberger, C. Bostedt, T. Möller, D. Rupp, M. Adolph, H. Graafsma, H. Hirsemann, K. Gärtner, R. Richter, L. Foucar, R. L. Shoeman, I. Schlichting, J. Ullrich,
"Large-format, high-speed, X-ray pnCCDs combined with electron and ion imaging spectrometers in a multipurpose chamber for experiments at 4th generation light sources",
Nucl. Instrum. Meth. A **614** (2010) 483.

M. Beye, F. Hennies, M. Deppe, E. Suljoti, M. Nagasono, W. Wurth, A. Föhlisch,
"Dynamics of electron phonon scattering: crystal- and angular-momentum transfer probed by resonant inelastic X-ray scattering",
Phys. Rev. Lett. **103** (2009) 237401.

G. Segneri, C. Brown, J.-D. Carpenter, B. Kuhnle, T. Lauf, P. Lechner, G. Lutz, S. Rummel, L. Strüder, J. Treis, C. Whitford,
"Measurement of the current related damage at -50 °C and consequences on macro-pixel detector operation",
IEEE T. Nucl. Sci. **56** (2009) 3734.

M. G. Pia, G. Weidenspointner, M. Augelli, L. Quintieri, P. Saracco, M. Sudhakar, A. Zoglauer,
"PIXE simulation with Geant4",
IEEE T. Nucl. Sci. **56** (2009) 3614.

M. Kremer, B. Fischer, B. Feuerstein, V. L. B. de Jesus, V. Sharma, C. Hofrichter, A. Rudenko, U. Thumm, C. D. Schröter, R. Moshammer, J. Ullrich,
"Electron localization in molecular fragmentation of H_2 by carrier-envelope phase stabilized laser pulses",
Phys. Rev. Lett. **103** (2009) 213003.

W. Quevedo, C. Peth, G. Busse, M. Scholz, K. Mann, S. Techert,
"Time-resolved soft X-ray diffraction reveals transient structural distortions of ternary liquid crystals",
Int. J. Mol. Sci. **10** (2009) 4754.

V. Averbukh, P. Kolorenč,
"Collective interatomic decay of multiple vacancies in clusters",
Phys. Rev. Lett. **103** (2009) 183001.

M. Rini, Y. Zhu, S. Wall, R. I. Tobey, H. Ehrke, T. Garl, J. W. Freeland, Y. Tomioka, Y. Tokura, A. Cavalleri, R. W. Schoenlein,
"Transient electronic structure of the photoinduced phase of $Pr_{0.7}Ca_{0.3}MnO_3$ probed with soft X-ray pulses",
Phys. Rev. B **80** (2009) 155113.

D. P. Bernstein, Y. Acremann, A. Scherz, M. Burkhardt, J. Stöhr, M. Beye, W. F. Schlotter, T. Beeck, F. Sorgenfrei, A. Pietzch, W. Wurth, A. Föhlisch,
"Near edge X-ray absorption fine structure spectroscopy with X-ray FELs",
Appl. Phys. Lett. **95** (2009) 134102.

A. J. Nelson, S. Toleikis, H. Chapman, S. Bajt, J. Krzywinski, J. Chalupsky, L. Juha, J. Cihelka, V. Hajkova, L. Vysin, T. Burian, M. Kozlova, R. R. Fäustlin, B. Nagler, S. M. Vinko, T. Whitcher, T. Dzelzainis, O. Renner, K. Saksl, A. R. Khorsand, P. A. Heimann, R. Sobierajski, D. Klinger, M. Jurek, J. Pelka, B. Iwan, J. Andreasson, N. Timneanu, M. Fajardo, J. S. Wark, D. Riley, T. Tschentscher, J. Hajdu, R. W. Lee,
"Soft X-ray FEL microfocus for exploring matter under extreme conditions",
Opt. Express **17** (2009) 18271.

J. Hallmann, W. Morgenroth, C. Paulmann, J. Davaasambuu, Q. Kong, M. Wulff, S. Techert,
"Time-resolved X-ray diffraction of the photochromic α-styrylpyrylium TFMS crystal films reveals ultrafast structural switching",
J. Am. Chem. Soc. **131** (2009) 15018.

M. Petri, G. Busse, W. Quevedo, S. Techert,
"Photo-induced phase transitions to liquid crystal phases: influence of the chain length from C_8E_4 to $C_{14}E_4$",
Materials **2** (2009) 1305.

J. Niskanen, M. Huttula, S. Heinäsmäki, J. Schulz, S. Urpelainen, K. Jänkälä, A. Moise, M. Alagia, L. Avaldi, K. C. Prince, R. Richter, S. Aksela, H. Aksela,
"Core level absorption of laser-excited Rb and Cs atoms",
J. Phys. B **42** (2009) 175001.

G. Zhu, M. Schuricke, J. Steinmann, J. Albrecht, J. Ullrich, I. Ben-Itzhak, T. J. M. Zouros, J. Colgan, M. S. Pindzola, A. Dorn,
"Controlling two-electron threshold dynamics in double photoionization of lithium by initial state preparation",
Phys. Rev. Lett. **103** (2009) 103008.

S. Wall, D. Prabakharan, A. T. Boothroyd. A. Cavalleri,
"Ultrafast coupling between light, coherent lattice vibrations, and the magnetic structure of semicovalent $LaMnO_3$",
Phys. Rev. Lett. **103** (2009) 097402.

M. Martins, M. Wellhöfer, A. A. Sorokin, M. Richter, K. Tiedtke, W. Wurth,
"Resonant multiphoton processes in the soft-X-ray regime",
Phys. Rev. A **80** (2009) 023411.

F. Filsinger, J. Küpper, G. Meijer, J. L. Hansen, J. Maurer, J. H. Nielsen, L. Holmegaard, H. Stapelfeldt,
"Pure samples of individual conformers: the separation of stereoisomers of complex molecules using electric fields",
Angew. Chem. Int. Ed. **48** (2009) 6900.

R. W. Lee, B. Nagler, U. Zastrau, R. Fäustlin, S. M. Vinko, T. Whitcher, R. Sobierajski, J. Krzywinski, L. Juha, A. J. Nelson, S. Bajt, K. Budil, R. C. Cauble, T. Bornath, T. Burian, J. Chalupsky, H. Chapman, J. Cihelka, T. Döppner, T. Dzelzainis, S. Düsterer, M. Fajardo, E. Förster, C. Fortmann, S. H. Glenzer, S. Göde, G. Gregori, V. Hajkova, P. Heimann, M. Jurek, F. Y. Khattak, A. R. Khorsand, D. Klinger, M. Kozlova, T. Laarmann, H.-J. Lee, K.-H. Meiwes-Broer, P. Mercere, W. J. Murphy, A. Przystawik, R. Redmer, H. Reinholz, D. Riley, G. Röpke, K. Saksl, R. Thiele, J. Tiggesbäumker, S. Toleikis, T. Tschentscher, I. Uschmann, R. W. Falcone, R. Shepherd, J. B. Hastings, W. E. White, J. S. Wark,
"Perspective for high energy density studies on X-ray FELs",
Proc. SPIE **7451** (2009) 74510E.

H. N. Chapman,
"X-Ray imaging beyond the limits",
Nat. Mater. **8** (2009) 299.

R. Gopal, K. Simeonidis, R. Moshammer, T. Ergler, M. Dürr, M. Kurka, K.-U. Kühnel, S. Tschuch, C.-D. Schröter, D. Bauer, J. Ullrich, A. Rudenko, O. Herrwerth, T. Uphues, M. Schultze, E. Goulielmakis, M. Uiberacker, M. Lezius, M. F. Kling,
"Three-dimensional momentum imaging of electron wave packet interferences in few-cycle laser pulses",
Phys. Rev. Lett. **103** (2009) 053001.

B. Nagler, U. Zastrau, R. R. Fäustlin, S. M. Vinko, T. Whitcher, A. J. Nelson, R. Sobierajski, J. Krzywinski, J. Chalupsky, E. Abreu, S. Bajt, T. Bornath, T. Burian, H. Chapman, J. Cihelka, T. Döppner, S. Düsterer, T. Dzelzainis, M. Fajardo, E. Förster, C. Fortmann, E. Galtier, S. H. Glenzer, S. Göde, G. Gregori, V. Hajkova, P. Heimann, L. Juha, M. Jurek, F. Y. Khattak, A. R. Khorsand, D. Klinger, M. Kozlova, T. Laarmann, H. J. Lee, R. W. Lee, K.-H. Meiwes-Broer, P. Mercere, W. J. Murphy, A. Przystawik, R. Redmer, H. Reinholz, D. Riley, G. Röpke, F. Rosmej, K. Saksl, R. Schott, R. Thiele, J. Tiggesbäumker, S. Toleikis, T. Tschentscher, I. Uschmann, H. J. Vollmer, J. S. Wark,
"Turning solid aluminium transparent by intense soft X-ray photoionization",
Nat. Phys. **5** (2009) 693.

S. Herres-Pawlis, S. Binder, A. Eich, R. Haase, B. Schulz, G. Wellenreuther, G. Henkel, M. Rübhausen, W. Meyer-Klaucke,
"Stabilization of a highly reactive bis(mu-oxo)dicopper(III) species at room temperature by electronic and steric constraint of an unconventional nitrogen donor ligand",
Chem.-Eur. J. **15** (2009) 8678.

H. B. Pedersen, S. Altevogt, B. Jordon-Thaden, O. Heber, L. Lammich, M. L. Rappaport, D. Schwalm, J. Ullrich, D. Zajfman, R. Treusch, N. Guerassimova, M. Martins, A. Wolf,
"Neutral and charged photofragment coincidence imaging with soft X-rays on molecular ion beams: breakup of H_3O^+ at 13.5 nm",
Phys. Rev. A **80** (2009) 012707.

R. Moshammer and J. Ullrich,
"Attosecond and X-ray FEL physics",
J. Phys. B **42** (2009) 130201.

B. Jordon-Thaden, H. B. Pedersen, S. Altevogt, O. Heber, L. Lammich, M. L. Rappaport, D. Schwalm, J. Ullrich, D. Zajfman, R. Treusch, N. Guerassimova, M. Martins, A. Wolf,
"Soft X-ray photolysis of the hydronium ion",
J. Phys. Conf. Ser. **194** (2009) 022074.

M. Kurka, A. Rudenko, L. Foucar, K. U. Kühnel, Y. H. Jiang, T. Ergler, T. Havermeier, M. Smolarski, S. Schössler, K. Cole, M. Schöffler, R. Dörner, M. Gensch, S. Düsterer, R. Treusch, S. Fritzsche, A. N. Grum-Grzhimailo, E. V. Gryzlova, N. M. Kabachnik, C. D. Schröter, R. Moshammer, J. Ullrich,
"Two-photon double ionization of Ne by FEL radiation: a kinematically complete experiment",
J. Phys. B **42** (2009) 141002.

H. Iwayama, K. Nagaya, M. Yao, H. Fukuzawa, X.-J. Liu, G. Prümper, M. Okunishi, K. Shimada, K. Ueda, T. Harada, M. Toyoda, M. Yanagihara, M. Yamamoto, K. Motomura, N. Saito, A. Rudenko, J. Ullrich, L. Foucar, A. Czasch, R. Dörner, N. Nagasono, A. Higashiya, M. Yabashi, T. Ishikawa, H. Ohashi, H. Kimura,
"Frustration of direct photoionization of Ar clusters in intense XUV Pulses from a FEL",
J. Phys. B **42** (2009) 124019.

Y. H. Jiang, A. Rudenko, M. Kurka, K. U. Kühnel, L. Foucar, T. Ergler, S. Lüdemann, K. Zrost, T. Ferger, D. Fischer, A. Dorn, J. Titze, T. Jahnke, M. Schöffler, S. Schössler, T. Havermeier, M. Smolarski, K. Cole, R. Dörner, T. J. M. Zouros, S. Düsterer, R. Treusch, M. Gensch, C. D. Schröter, R. Moshammer, J. Ullrich,
"EUV-photon-induced multiple ionization and fragmentation dynamics: from atoms to molecules",
J. Phys. B **42** (2009) 134012.

K. Motomura, L. Foucar, A. Czasch, N. Saito, O. Jagutzki, H. Schmidt-Böcking, R. Dörner, X.-J. Liu, H. Fukuzawa, G. Prümper, K. Ueda, M. Okunishi, K. Shimada, T. Harada, M. Toyoda, M. Yanagihara, M. Yamamoto, H. Iwayama, K. Nagaya, M. Yao, A. Rudenko, J. Ullrich, M. Nagasono, A. Higashiya, M. Yabashi, T. Ishikawa, H. Ohashi, H. Kimura,
"Multi-coincidence ion detection system for EUV–FEL fragmentation experiments at SPring-8",
Nucl. Instrum. Meth. A **606** (2009) 770.

H. Zhang, D. Rolles, J. D. Bozek, N. Berrah,
"Photoionization of Ar clusters in the Ar 3s -> *n*p Rydberg resonance region",
J. Phys. B **42** (2009) 105103.

X.-J. Liu, H. Fukuzawa, G. Prümper, M. Okunishi, K. Shimada, K. Ueda, K. Motomura, N. Saito, H. Iwayama, K. Negaya, M. Yao, A. Rudenko, J. Ullrich, L. Foucar, A. Czasch, H. Schmidt-Böcking, R. Dörner, N. Nagasono, A. Higashiya, M. Yabashi, T. Ishikawa, H. Ohashi, H. Kimura,
"Cold-target recoil-ion momentum spectroscopy for diagnostics of high harmonics of the XUV FEL Light Source at SPring-8",
Rev. Sci. Instrum. **80** (2009) 053105.

J.-M. Rost,
"Complex non-equilibrium dynamics in plasmas",
European Rev. **17** (2009) 249.

C. Gnodtke, U. Saalmann, J. M. Rost,
"Ionization and charge migration through strong internal fields in clusters exposed to intense X-ray pulses",
Phys. Rev. A **79** (2009) 041201(R).

V. Senz, T. Fischer, P. Oelßner, J. Tiggesbäumker, J. Stanzel, C. Bostedt, H. Thomas, M. Schöffler, L. Foucar, M. Martins, J. Neville, M. Neeb, T. Möller, W. Wurth, E. Rühl, R. Dörner, H. Schmidt-Böcking, W. Eberhardt, G. Ganteför, R. Treusch, P. Radcliffe, K. H. Meiwes-Broer,
"Core-hole screening as a probe for a metal-to-nonmetal transition in lead clusters",
Phys. Rev. Lett. **102** (2009) 138303.

A. Castoldi, C. Guazzoni, R. Hartmann, P. Madoglio, L. Strüder,
"Analysis and characterization of pre-diffusion in multi-linear silicon drift detectors",
IEEE T. Nucl. Sci. **56** (2009) 496.

Y. H. Jiang, A. Rudenko, M. Kurka, K. U. Kühnel, T. Ergler, L. Foucar, M. Schöffler, S. Schössler, T. Havermeier, M. Smolarski, K. Cole, R. Dörner, S. Düsterer, R. Treusch, M. Gensch, C. D. Schröter, R. Moshammer, J. Ullrich,
"Few-photon multiple ionization of N_2 by XUV FEL radiation",
Phys. Rev. Lett. **102** (2009) 123002.

H. Fukuzawa, X.-J. Liu, G. Prümper, M. Okunishi, K. Shimada, K. Ueda, T. Harada, M. Toyoda, M. Yanagihara, M. Yamamoto, H. Iwayama, K. Nagaya, M. Yao, K. Motomura, N. Saito, A. Rudenko, J. Ullrich, L. Foucar, A. Czasch, R. Dörner, M. Nagasono, A. Higashiya, M. Yabashi, T. Ishikawa, H. Ohashi, H. Kimura,
"Dead-time-free ion momentum spectroscopy of multiple ionization of Xe clusters irradiated by EUV FEL pulses",
Phys. Rev. A **79** (2009) 031201(R).

C. Bostedt, H. N. Chapman, J. T. Costello, J. R. Crespo López-Urrutia, S. Düsterer, S. W. Epp, J. Feldhaus, A. Föhlisch, M. Meyer, T. Möller, R. Moshammer, M. Richter, K. Sokolowski-Tinten, A. Sorokin, K. Tiedtke, J. Ullrich, W. Wurth,
"Experiments at FLASH",
Nucl. Instrum. Meth. A **601** (2009) 108.

J. Treis, R. Andritschke, R. Hartmann, S. Herrmann, P. Holl, T. Lauf, P. Lechner, G. Lutz, N. Meidinger, M. Porro, R. H. Richter, F. Schopper, H. Soltau, L. Strüder,
"Pixel detectors for X-ray imaging spectroscopy in space",
J. Instrum. **4** (2009) P033012.

M. R. Howells, T. Beetz, H. N. Chapman, C. Cui, J. M. Holton, C. J. Jacobsen, J. Kirz, E. Lima, S. Marchesini, H. Miao, D. Sayre, D. A. Shapiro, J. C. H. Spence, D. Starodub,
"An assessment of the resolution limitation due to radiation-damage in X-ray diffraction microscopy",
J. Electron Spec. **170** (2009) 4.

L. Redecke, S. Binder, M. I. Y. Elmallah, R. Broadbent, C. Tilkorn, B. Schulz, P. May, A. Goos, A. Eich, M. Rübhausen, C. Betzel,
"UV-light-induced conversion and aggregation of prion proteins",
Free Radical Biol. Med. **46** (2009) 1353.

D. Rolles, H. Zhang, Z. D. Pešic, J. D. Bozek, N. Berrah,
"Emergence of valence band structure in rare-gas clusters",
Chem. Phys. Lett. **468** (2009) 148.

L. Holmegaard, J. H. Nielsen, I. Nevo, H. Stapelfeldt, F. Filsinger, J. Küpper, G. Meijer,
"Laser-induced alignment and orientation of quantum-state-selected large molecules",
Phys. Rev. Lett. **102** (2009) 023001.

H. Zhang, D. Rolles, Z. D. Pešic, J. D. Bozek, N. Berrah,
"Angular distributions of inner-shell photoelectrons from rare-gas clusters",
Phys. Rev. A **78** (2008) 063201.

R. I. Tobey, R. Prabakharan, A. T. J. Boothroyd, A. Cavalleri,
"Ultrafast electronic phase transition in $La_{1/2}Sr_{3/2}MnO_4$ by coherent vibrational excitation: evidence for nonthermal melting of orbital order",
Phys. Rev. Lett. **101** (2008) 197404.

D. A. Shapiro, H. N. Chapman, D. DePonte, R. B. Doak, P. Fromme, G. Hembree, M. Hunter, S. Marchesini, K. Schmidt, J. Spence, D. Starodub, U. Weierstall,
"Powder diffraction from a continuous microjet of submicron protein crystals",
J. Synchrotron Radiat. **15** (2008) 593.

A. G. Kochur, I. D. Petrov, J. Schulz, P. Wernet,
"Term-dependent lifetime broadening effect on the 4d photoelectron spectrum of atomic thulium",
J. Phys. B **41** (2008) 215002.

K. E. Schmidt, J. C. H. Spence, U. Weierstall, R. Kirian, X. Wang, D. Starodub, H. N. Chapman, M. R. Howells, R. B. Doak,
"Tomographic femtosecond X-ray diffractive imaging",
Phys. Rev. Lett. **101** (2008) 115507.

W. Leitenberger, R. Hartmann, U. Pietsch, R. Andritschke, I. Starke, L. Strüder,
"Application of a pnCCD in X-ray diffraction: a three dimensional X-ray detector",
J. Synchrotron Radiat. **15** (2008) 449.

J. Schulz, E. Loos, M. Huttula, S. Heinäsmäki, S. Svensson, S. Aksela, H. Aksela,
"A method to characterize electronic states of 4s ionized Rb by combined laser and synchrotron spectroscopy",
Europhys. Lett. **83** (2008) 53001.

A. Rudenko, L. Foucar, M. Kurka, T. Ergler, K. U. Kühnel, Y. H. Jiang, A. Voitkiv, B. Najjari, A. Kheifets, S. Lüdemann, T. Havermeier, M. Smolarski, S. Schössler, K. Cole, M. Schöffler, R. Dörner, S. Düsterer, W. Li, B. Keitel, R. Treusch, M. Gensch, C. D. Schröter, R. Moshammer, J. Ullrich,
"Recoil-ion momentum distributions for two-photon double ionization of He and Ne by 44 eV FEL radiation",
Phys. Rev. Lett. **101** (2008) 073003.

S. Fritzsche, A. N. Grum-Grzhimailo, E. V. Gryzlova, N. M. Kabachnik,
"Angular distributions and angular correlations in sequential two-photon double ionization of atoms",
J. Phys. B **41** (2008) 165601.

S. Marchesini, S. Boutet, A. E. Sakdinawat, M. J. Bogan, S. Bajt, A. Barty, H. N. Chapman, M. Frank, S. P. Hau-Riege, A. Szöke, C. Cui, D. A. Shapiro, M. R. Howells, J. C. H. Spence, J. W. Shaevitz, J. Y. Lee, J. Hajdu, M. M. Seibert,
"Massively parallel X-ray holography",
Nat. Photonics **2** (2008) 560.

H. N. Chapman,
"Focus on X-ray Diffraction",
Science **321** (2008) 352.

S. Boutet, M. J. Bogan, A. Barty, M. Frank, W. H. Benner, S. Marchesini, M. M. Seibert, J. Hajdu, H. N. Chapman,
"Ultrafast soft X-ray scattering and reference-enhanced diffractive imaging of weakly scattering nanoparticles",
J. Electron Spec. **166-167** (2008) 65.

W. Quevedo, M. Petri, G. Busse, S. Techert,
"On the mechanism of photoinduced phase transitions in ternary liquid crystal systems near thermal equilibrium",
J. Chem. Phys. **129** (2008) 024502.

A. Barty, S. Boutet, M. J. Bogan, S. Hau-Riege, S. Marchesini, K. Sokolowski-Tinten, N. Stojanovic, R. Tobey, H. Ehrke, A. Cavalleri, S. Düsterer, M. Frank, S. Bajt, B. W. Woods, M. M. Seibert, J. Hajdu, R. Treusch, H. N. Chapman,
"Ultrafast single-shot diffraction imaging of nanoscale dynamics",
Nat. Photonics **2** (2008) 415.

J. Ullrich, B. Feuerstein, W. Wurth,
"Trendbericht Physikalische Chemie 2007: Freie-Elektronen-Laser",
Nachr. Chem. **56** (2008) 311.

B. Zimmermann, D. Rolles, B. Langer, R. Hentges, M. Braune, S. Cvejanovic, O. Geßner, F. Heiser, S. Korica, T. Lischke, A. Reinköster, J. Viefhaus, R. Dörner, V. McKoy, U. Becker,
"Localization and loss of coherence in molecular double-slit experiments",
Nat. Phys. **4** (2008) 649.

B. Hornberger, M. D. de Jonge, M. Feser, P. Holl, C. Holzner, C. Jacobsen, D. Legnini, D. Paterson, F. Rehak, L. Strüder, S. Vogt,
"Differential phase contrast with a segmented detector in a scanning X-ray microprobe",
J. Synchrotron Radiat. **15** (2008) 355.

W. Quevedo, M. Petri, S. Techert,
"Home-based time-resolved photo small angle X-ray diffraction and its application",
Z. Kristallogr. **223** (2008) 322.

S. P. Hau-Riege and H. N. Chapman,
"Modeling of the damage dynamics of nanospheres exposed to X-ray FEL radiation",
Phys. Rev. E **77** (2008) 041902.

S. Bajt, H. N. Chapman, E. A. Spiller, J. B. Alameda, B. W. Woods, M. Frank, M. J. Bogan, A. Barty, S. Boutet, S. Marchesini, S. P. Hau-Riege, J. Hajdu, D. Shapiro,
"Camera for coherent diffractive imaging and holography with a soft-X-ray FEL",
Appl. Opt. **47** (2008) 1673.

U. Saalmann, I. Georgescu, J. M. Rost,
"Tracing non-equilibrium plasma dynamics on the attosecond timescale in small clusters",
New J. Phys. **10** (2008) 025014.

M. Wellhöfer, J. T. Hoeft, M. Martins, W. Wurth, M. Braune, J. Viefhaus, K. Tiedtke, M. Richter,
"Photoelectron spectroscopy as non-invasive method to monitor SASE-FEL spectra",
J. Instrum. **3** (2008) 2003.

C. Gahl, A. Azima, M. Beye, M. Deppe, K. Döbrich, U. Hasslinger, F. Hennies, A. Melnikov, M. Nagasono, A. Pietzsch, M. Wolf, W. Wurth, A. Föhlisch,
"A femtosecond X-ray/optical cross-correlator",
Nat. Photonics **2** (2008) 165.

M. J. Bogan, W. H. Benner, S. Boutet, U. Rohner, M. Frank, A. Barty, M. M. Seibert, F. Maia, S. Marchesini, S. Bajt, B. Woods, V. Riot, S. P. Hau-Riege, M. Svenda, E. Marklund, E. Spiller, J. Hajdu, H. N. Chapman,
"Single particle X-ray diffractive imaging",
Nano Lett. **8** (2008) 310.

I. Georgescu, U. Saalmann, J. M. Rost,
"Attosecond resolved charging of ions in a rare-gas cluster",
Phys. Rev. Lett. **99** (2007) 183002.

I. Georgescu, U. Saalmann, J. M. Rost,
"Clusters under strong VUV pulses: a quantum-classical hybrid-description incorporating plasma effects",
Phys. Rev. A **76** (2007) 043203.

S. W. Epp, J. R. Crespo López-Urrutia, G. Brenner, V. Mäckel, P. H. Mokler, R. Treusch, M. Kuhlmann, M. V. Yurkov, J. Feldhaus, J. R. Schneider, M. Wellhöfer, M. Martins, W. Wurth, J. Ullrich,
"Laser spectroscopy on trapped highly-charged ions using soft X-rays from FLASH",
J. Phys. Conf. Ser. **88** (2007) 012059.

H. B. Pedersen, S. Altevogt, B. Jordon-Thaden, O. Heber, M. L. Rappaport, D. Schwalm, J. Ullrich, D. Zajfman, R. Treusch, N. Guerassimova, M. Martins, J.-T. Hoeft, M. Wellhöfer, A. Wolf,
"Crossed beam photodissociation imaging of HeH^+ with vacuum UV FEL pulses",
Phys. Rev. Lett. **98** (2007) 223202.

R. Moshammer, Y. H. Jiang, L. Foucar, A. Rudenko, T. Ergler, C. D. Schröter, S. Lüdemann, K. Zrost, D. Fischer, J. Titze, T. Jahnke, M. Schöffler, T. Weber, R. Dörner, T. J. M. Zouros, A. Dorn, T. Ferger, K. U. Kühnel, S. Düsterer, R. Treusch, P. Radcliffe, E. Plönjes, J. Ullrich,
"Few-photon multiple ionization of Ne and Ar by strong FEL pulses",
Phys. Rev. Lett. **98** (2007) 203001.

S. W. Epp, J. R. Crespo López-Urrutia, G. Brenner, V. Mäckel, P. H. Mokler, R. Treusch, M. Kuhlmann, M. V. Yurkov, J. Feldhaus, J. R. Schneider, M. Wellhöfer, M. Martins, W. Wurth, J. Ullrich,
"Soft X-ray laser spectroscopy on trapped highly charged ions at FLASH",
Phys. Rev. Lett. **98** (2007) 183001.

C. Blome, T. Tschentscher, J. Davaasambuu, P. Durand, S. Techert,
"Ultrafast time-resolved powder diffraction using FEL radiation",
Synchrotron Radiat. Instr. - AIP Conf. Proc. **879** (2007) 1254.

PATENTS

G. Lutz, R. Richter, L. Strüder,
"Semiconductor structure, particularly in a semiconductor detector, and associated operating method",
US 7518203B2.

L. Strüder, G. Lutz,
"DEPFET transistor having a large dynamic range",
Pub. No.: WO/2009/049808,
International Application No.: PCT/EP2008/008489.

INVITED TALKS OF CFEL SCIENTISTS

2010

A. Aquila
"Multilayer optics for femtosecond/attosecond sources",
Int. Conf. on the Physics of X-ray Multilayer Structures, Big Sky, MT, USA, 15.2.2010.

V. Averbukh
"Intra- and inter-atomic decay processes in multiply ionized clusters",
15th Int. Workshop "Quantum Systems in Chemistry and Physics", Cambridge, UK, 31.8.-5.9.2010.
"Attosecond to picosecond electronic decay processes in multiply ionized molecules and clusters",
Workshop "Advances in Strong-Field and Attosecond Physics", London, UK, 23.-25.6.2010.

A. Barty
"Femtosecond imaging using X-ray FELs",
University of Groningen, Netherlands, 28.10.2010.
1. **"Offline analysis of LCLS imaging data"**,
2. **"Femtosecond coherent diffraction imaging"**,
LCLS/SSRL Annual Users' Meeting & Workshops, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 17.-21.10.2010.
"Ultrafast single-shot diffraction imaging of nanoscale dynamics",
32st Int. FEL Conf., Malmö, Sweden, 22.-27.8.2010.
"Femtosecond X-ray imaging using FELs",
10th Int. Conf. on X-ray Microscopy (XRM2010), Chicago, IL, USA, 15.-20.8.2010.
"Single-particle imaging with pulsed hard X-ray lasers",
Gordon Conf. on Diffraction Methods in Structural Biology, Bates College, Lewiston, ME, USA, 18.-23.7.2010.
"Nanocrystallography with X-ray FELs",
University of Hamburg, Hamburg, Germany, 8.7.2010.
"Nanocrystallography with X-ray FELs",
EMBO Conf. Series: Catalytic mechanisms by biological systems: at the interface between chemistry and biology, EMBL, Hamburg, Germany, 5.-7.5.2010.
"Biological imaging using FELs",
Imaging and life sciences applications of new light sources, Italian Embassy, London, UK, 26.3.2010.
1. **"Pump probe timing at FLASH / XFEL"**,
2. **"State of the art X-ray optics"**,
48th ICFA Advanced Beam Dynamics Workshop on Future Light Sources, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 1.-5.3.2010.

U. Becker
"FEL and synchrotron radiation at DESY, Germany and LBNL and SLAC in the United States",
College of Science, King Saud University, Riyadh, Saudi Arabia, 25.10.2010.

A. Cavalleri
"Making superconductivity with light",
Colloquium, Ecole Polytechnique Federal Lausanne, Lausanne Switzerland, 13.12.2010.
"Controlling superconductivity with light",
ALS, Berkeley, CA, USA, 9.11.2010.
"Light-induced superconductivity",
Department of Physics, Stanford University, Stanford, CA, USA, 18.10.2010.
"Inducing superconductivity with light",
Colloquium, MPI for the Physical Chemistry of Solids, Dresden, Germany, 7.10.2010.
"Inducing superconductivity with light",
SFB Symp., Cologne, Germany, 8.9.2010.
"Light-induced superconductivity",
Colloquium, MPI for Nuclear Research, Heidelberg, Germany, 15.7.2010.
"Controlling metal-insulator transitions with light",
Gordon Conf. on Correlated Electron Systems, South Hadley, MA, USA, 13.-18.6.2010.
"Controlling strongly correlated electrons with light",
Berkeley Lab Symp. on New Light Sources, Berkeley, CA, USA, 6.5.2010.
"Photo-control in complex solids",
Colloquium, Ecole Polytechnique, Paris, France, 29.4.2010.
"Photo-control in complex solids",
Colloquium, ETH Zuerich, Switzerland, 17.3.2010.
"Controlling superconductors with light",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.
"Controlling metal-insulator transitions with light",
Gordon Conf. on Ultrafast Phenomena in Cooperative Systems, Galveston, TX, USA, 28.2.-5.3.2010.
"Light control in complex solids",
1st Banff Meeting on Structural Dynamics, Banff, Canada, 25. -28.2.2010.
"Photo-control in complex solids",
Physics Colloquium, University of Kiel, Kiel, Germany, 2.2.2010.

H. N. Chapman
"Villigen update report",
Int. workshop on the soft X-ray science and instrumentation at the European XFEL, Trieste, Italy, 16.-17.12.2010.
"Time-resolved imaging and diffraction with X-ray FELs",
Workshop on Seeded FEL Sources and Time-Resolved Experiments, Trieste, Italy, 14.-15.12.2010.
"Femtosecond coherent X-ray nanocrystallography at LCLS",
IMSS Symp. 2010 (Prospects of Quantum Beam Sciences), Tsukuba Congress Center, Japan, 7.-8.12.2010.
"Femtosecond nanocrystallography with X-ray FELs",
Michaelmas Colloquium, Dept. of Physics, University of Oxford, UK, 26.11.2010.
"Femtosecond X-ray nanocrystallography",
Bjorn H. Wiik Prize Lecture, DESY, Hamburg, Germany, 15.11.2010.
"Imaging at the bright, brighter, and brightest",
ALS Users' Meeting, Berkeley, CA, USA, 13.-15.10.2010.
"Femtosecond coherent X-ray nanocrystallography at LCLS",
34th Annual Meeting NNV AMO, Lunteren, Netherlands, 11.-12.10.2010.
"Femtosecond X-ray protein nanocrystallography",
26th European Crystallographic Meeting, Darmstadt, Germany, 29.8.-2.9.2010.
"Coherent X-ray diffractive imaging at the LCLS",
37th Int. Conf. on Vacuum UV and X-ray Physics, Vancouver, Canada, 11.-16.7.2010.
1. **"Coherent diffractive imaging"**,
2. **"Prospects for molecular imaging"**,
UXSS 2010, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 21.-24.6.2010.
"First bio-imaging results from LCLS",
SLAC Colloquium, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 7.6.2010.
"Coherent nanocrystallography and imaging at LCLS",
SLAC Science Policy Meeting, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 7.-8.5.2010.
"Coherent imaging of protein nanocrystals at the LCLS X-ray FEL",
Stanford University, Stanford, CA, USA, 7.5.2010.
"X-ray laser diffraction",
Gedenkkolloquium zum 50. Todestag von Max von Laue, Physikalische Gesellschaft zu Berlin, TU Berlin, Germany, 23.4.2010.
"Coherent nanocrystallography and imaging at LCLS",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.
"Coherent diffractive imaging at LCLS",
DPG Spring Meeting of the Section AMOP, Hannover, Germany, 8.-12.3.2010.
"Imaging experiments at LCLS and FLASH",
2nd IRUVX-PP Annual Meeting, Schorfheide, Germany, 2.-4.3.2010.
"First results of coherent diffraction experiments at LCLS",
1st Banff Meeting on Structural Dynamics, Banff, Canada, 25.-28.2.2010.

J. Crespo López-Urrutia
"Status of the ion traps experiments Aarhus-Heidelberg",
Workshop on "Soft X-Ray Science and Instrumentation at the European XFEL", Trieste, Italy, 16.-17.12.2010.
"Astrophysical highly charged ions brought to the laboratory",
HZB BESSY Users Meeting, Berlin, Germany, 10.12.2010.
"Electron beam ion trap end station",
LCLS/SSRL Annual Users' Meeting & Workshops, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 17.-21.10.2010.
"Resonance scattering and photoionization in $Fe^{14+,15+}$ ions at 800 eV photon energy",
15th Int. Conf. on the Physics of Highly Charged Ions (HCI 2010), Shanghai, China, 30.8.-3.9.2010.

"Photoionizing highly charged ions up to Fe^{15+} with X rays: resonance scattering",
10th European Conf. on Atoms, Molecules and Photons (ECAMP10), Salamanca, Spain, 4.-9.7.2010.
"Photoionization of trapped ions at synchrotrons and free-electron X-ray lasers",
5th Conf. on trapped charged particles and fundamental interactions, Saariselkä, Finland, 12.-16.4.2010.
"Photoionization of trapped ions at synchrotrons and free-electron X-ray lasers",
Int. Symp. on Electron Beam Ion Sources and Traps (EBIST2010), Stockholm, Sweden, 7.-10.4.2010.
"Photoionization measurements of Ar and Fe highly charged ions in the keV regime",
Conf. on High-resolution X-ray spectroscopy: past, present, and future, Utrecht, Netherlands, 15.-17.3.2010.
"Reenacting photoionization in astrophysical X-ray engines at LCLS",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.
"Exciting and ionizing trapped highly charged ions with electrons and photons in an EBIT",
DPG Spring Meeting, Joint Symp. SYPS, Hannover, Germany, 8.-12.3.2010.

A. Dorn
"A lithium target for experiments at FELs",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.

S. W. Epp
"The CAMP instrument and electron holography",
Int. Focus Workshop "Molecules under X-ray Pulses", Dresden, Germany, 15.-17.11.2010.
"pnCCD detectors for imaging",
LCLS/SSRL Annual Users' Meeting & Workshops, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 17.-21.10.2010.
"The Advanced Study Group and CAMP",
Joint Workshop of the MPG BMS and CPTS Divisions on Research Perspectives with FELs, Reisensburg, Germany, 27.-29.9.2010.
"FEL photons on trapped ions in EBITs",
Int. Conf. on the Application of Accelerators in Research and Industry (CAARI 2010), Fort Worth, TX, USA, 9.-13.8.2010.
"Results & experiences for the pnCCDs in CAMP",
7th XDAC meeting, Hamburg, Germany, DESY, 25.5.2010.

Y. Jiang
"Progress on atomic and molecular physics with strong lasers in Heidelberg",
8th CCAST Workshop on Strong Field Laser Physics, Shanghai, China, 25.-29.10.2010.
"Two-photon double ionization of D_2 by XUV pump-probe experiments at FLASH",
37th Int. Conf. on Vacuum UV and X-ray Physics (VUVX), Vancouver, Canada, 11.-16.7.2010.
"XUV pump-probe measurements with atoms and molecules at FLASH and SCSS",
First meeting of the ATTOFEL network, Lund, Sweden, 27.-28.5.2010.
"Overview of FEL studies in Heidelberg",
Physics Department, University of Freiburg, Freiburg, Germany, 10.5.2010.

F. Krasniqi
"Opportunities in solid state physics",
Joint Workshop of the MPG BMS and CPTS Divisions on Research Perspectives with FELs, Reisensburg, Germany, 27.-28.9.2010.
"Photoelectron holographic imaging of molecules with FELs",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.
"Ultra-fast, Ångström scale structure determination of molecules via photoelectron holography",
1st Banff Meeting on Structural Dynamics, Banff, Canada, 25.-28.2.2010.

J. Küpper
"Manipulating the motion of large molecules: information from the molecular frame",
CFEL, Hamburg, Germany, 6.1.2010.

A. Mikaberidze
"Coulomb explosions of atomic and molecular clusters",
LCAR, IRSAMC, CNRS, Université Paul Sabatier, Toulouse, France, Jun. 2010.

R. J. D. Miller
"Making the molecular movie: first frames",
Colloquium MPI for Nuclear Physics, Heidelberg, Germany, Nov. 2010.
"Making the molecular movie: first frames",
Int. Focus Workshop "Molecules under X-ray Pulses", Dresden, Germany, 15.-17.11.2010.
"Do we live in a quantum world? A new twist",
ADLIS Symp., Vienna, Austria, 28.-29.10.2010.
"Making the molecular movie: first frames",
Workshop on "Science with FLASH", Hamburg, Germany, 27.-29.10.2010.
"Atomically resolved structural dynamics: material issues for XFEL studies and some solutions",
Dutch meeting on Molecular and Cellular Biophysics, Veldhoven, Netherlands, 4.-5.10.2010.
"The scientific case for the relativistic electron gun for atomic exploration",
Workshop, DESY, Hamburg, Germany, Oct. 2010.
"Making the molecular movie: first frames",
David Rankin Symp., Edinburgh, Scotland, 17.9.2010.
1. **"Do we live in a quantum world? A new twist"**,
2. **"Making the molecular movie: first frames"**,
GCOE, Japan, Sep. 2010.
"Making the molecular movie: first frames",
ICPEPA-7, Copenhagen, Denmark, 15.-19.8.2010.
"Making the molecular movie: first frames",
Microscopy & Microanalysis 2010, Portland, OE, USA, 1.-5.8.2010.
"Making the molecular movie: first frames",
American Crystallography Meeting, Chicago, IL, USA, 24.-29.7.2010.
"Making the molecular movie: first frames",
17th Int. Conf. on Ultrafast Phenomena, Snowmass, CO, USA, 18.-23.7.2010.

R. Moshammer
"Time-resolved molecular break-up reactions",
Int. Focus Workshop "Molecules under X-ray Pulses", Dresden, Germany, 15.-17.11.2010.
"Atoms and molecules in strong fields at IR and XUV wavelengths",
Imperial College, London, England, 15.9.2010.
"XUV pump-probe experiments at FELs",
Int. Conf. on Many Particle Spectroscopy of Atoms, Molecules and Clusters (MPS2010), Sendai, Japan, 4.-7.9.2010.
"Break-up of atoms and molecules in intense FEL radiation",
Gordon Research Conf. on Multiphoton Processes, Tilton, NH, USA, 6.-11.6.2010.
"Atomic physics experiments at the free-electron laser FLASH",
Symp. "Trends in Experimental Physics: Multi-Particle Coincidence Spectroscopy of Atoms and Molecules", Uppsala, Sweden, 28.5.2010.

D. Rolles
"Recent results from the AMO beamline at LCLS",
Int. Workshop on Soft X-ray Science and Instrumentation at the European XFEL, Trieste, Italy, 16.-17.12.2010.
"Scientific case for the second generation instrument in the AMO hutch",
LCLS/SSRL Annual Users' Meeting & Workshops on AMO Science Opportunities and Instrumentation Needs, Menlo Park, CA, USA, 17.-20.10.2010.
"Probing molecular dynamics with FELs",
Science with FLASH: Recent Results and Future Perspectives, Hamburg, Germany, 27.-29.9.2010.
"Femtosecond photoelectron diffraction and photoelectron holography",
Joint Workshop of the MPG BMS and CPTS Divisions on Research Perspectives with FELs, Reisensburg, Germany, 27.-29.9.2010.
"Time-resolved photoelectron diffraction on laser-aligned molecules",
37th Int. Conf. on Vacuum Ultraviolet and X-ray Physics (VUVX 2010), Vancouver, Canada, 11.-16.7.2010.
"Time-resolved photoelectron diffraction on laser-aligned molecules",
Int. Conf. on Many Particle Spectroscopy of Atoms, Molecules, Clusters and Surfaces (MPS2010), Sendai, Japan, 4.-7.9.2010.
"Correlated electron, ion and fluorescence spectroscopy after XFEL ionization of atoms and molecules - first results from the CAMP instrument at LCLS",
MPSD@CFEL, Hamburg, Germany, 24.3.2010.
"Competition between radiative and Auger decay after XFEL ionization of atoms and molecules",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.

"X-ray detectors for next-generation X-ray sources - the fine art of high-speed X-ray imaging",
48th ICFA Advanced Beam Dynamics Workshop on Future Light Sources, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 1.-5.3.2010.
"Competition between radiative and Auger decay after XFEL ionization of atoms and molecules",
1st Banff Meeting on Structural Dynamics, Banff, Canada, 25.-28.2.2010.
"Harder, brighter, shorter - first experiments at the Stanford X-ray FEL",
Bothe-Colloquium, MPI for Nuclear Physics, Heidelberg, Germany, 20.1.2010.

J. M. Rost
"Dynamics of photo activated Coulomb complexes",
MiniSymp. on Matter in "New Light Sources", Aarhus, Denmark, 16.9.2010.
"Ultrafast or ultrashort: extreme atomic dynamics with finite nanoplasmas",
25th Summer School and Int. Symp. on the Physics of Ionized Gases, Donji Milanovac, Serbia, 29.8.-3.9.2010.
"Photo activated Coulomb complexes",
Kavli Institute for Theoretical Physics, Santa Barbara, CA, USA, 16.8.2010.
"Nonlinear driving of atoms with intense light fields",
Advances in Strong-Field and Attosecond Physics, UCL, London, UK, 23.-25.6.2010.
"Ultrafast or ultrashort: extreme atomic dynamics",
Conf. "150th orbit of Alexander von Humboldt", Havana, Cuba, 7.-11.6.2010.
"Nonlinear driving of atoms by intense light fields",
ETH, Zürich, 29.3.2010.
"Fast electron migration: a universal phenomenon under XFEL and attosecond light pulses",
Vienna University of Technology, Vienna, Austria, 15.1.2010.

A. Rudenko
"Towards time-resolved imaging of dynamics in clusters, nanocrystals and viruses",
Int. Focus Workshop "Molecules under X-ray Pulses", Dresden, Germany, 15.-17.11.2010.
"First experiments at LCLS: correlated ion, electron and photon spectroscopy",
CUSPFEL "Chemistry with Ultrashort Pulses and FELs" Workshop, Hersonissos, Greece, 20.-22.10.2010.
"Few-particle reactions in intense FEL light: first experiments in the X-ray domain",
EMMI Workshop "Particle dynamics under extreme matter conditions", Speyer, Germany, 26.-29.9.2010.
"Atoms and molecules in intense FEL light: from EUV to X-ray domain",
Int. Conf. on Coherent and Nonlinear Optics / Int. Conf. on Lasers, Applications and Technologies (ICONO/LAT), Kazan, Russia, 23.-26.8.2010.
"Atomic and molecular fragmentation by intense FEL light: from VUV to X-ray domain",
Ultrafast Vacuum Ultraviolet and X-ray Physics Workshop, Menlo Park, CA, USA, 19.-21.7.2010.
"Exploring few-photon, few-electron reactions with FELs: from ion yield and momentum measurements to time-resolved and kinematically complete experiments",
CUSPFEL "Chemistry with Ultrashort Pulses and FELs" WG1 meeting, Han-sur-Lesse, Belgium, 12.-16.4.2010.
"X-ray pump, X-ray probe experiments: experience from FLASH and SCSS, perspectives for LCLS",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.
"Time-resolved imaging of few-photon, few-electron reactions",
Gordon Research Conf. on Photoions, Photoionization and Photodetachment, Galveston, TX, USA, 31.-5.2.2010.

U. Saalmann
"Clusters in strong XUV and X-ray pulses: electron emission and proton ejection",
Conf. on "Many-Particle Spectroscopy of Atoms, Molecules, Clusters and Surfaces", Sendai, Japan, 4.-7.11.2010.
"Coulomb complexes: Ionization dynamics in FEL-driven clusters",
COST 3rd annual meeting, Crete, Greece, 19.-23.10.2010.
"Nanoplasma dynamics in FEL-driven atomic clusters",
KITP Conf. "X-ray Science in the 21st Century", Santa Barbara, CA, USA, 2.-6.8.2010.
"Formation of novel nanoplasmas in atomic clusters",
Imperial College, London, UK, 19.6.2010.
"Formation of novel nanoplasmas in atomic clusters",
UCL, London, UK, 6.5.2010.
"Formation of novel nanoplasmas in atomic clusters",
Martin Luther University, Halle, 26.4.2010.
"Electron emission through collisional auto-ionization in FEL pulses",
COST workgroup meeting, Trieste, Italy, 22.-24.4.2010.

R. Santra
"Hole dynamics and coherence",
Imperial College, London, UK, 3.12.2010.
"Ultrafast processes at high X-ray intensity",
Colloquium, MPI for Quantum Optics, Garching, Germany, 15.11.2010.
"Ultrafast processes at high X-ray intensity",
Physics Colloquium at the University of Göttingen, Göttingen, Germany, 8.11.2010.
"Hole dynamics and coherence",
Workshop on "Science with FLASH", Hamburg, Germany, 27.-29.10.2010.
"X-ray frontiers",
Kavli Institute for Theoretical Physics, Santa Barbara, CA, USA, 16.8.2010.

J. Schneider
"The road to the European XFEL: a European research facility born at DESY",
European XFEL Users' Meeting, DESY, Hamburg, Germany, 27.1.2010.
"Science at the VUV FEL FLASH at DESY",
5th Future Light Source Workshop 2010: Science and Technology, Pohang, South Korea, 9.-10.2.2011.
"Science at X-ray FELs: potential for structural biology",
Biology and Synchrotron Radiation BSR 2010, Melbourne, Australia, 15.-18.2.2010.
"Scientific highlights from operation of FLASH and new opportunities with LCLS",
CLEO/QELS: 2010, Laser Science to Photonic Applications, San Jose, CA, USA, 16.-21.5.2010.
"The Coherent Light Source LCLS at SLAC: facility and early science",
Workshop of the BE/OPT-XFEL project, Athens, Greece, 18.-19.6.2010.

M. Schnell
"Dynamics of cold and controlled molecules",
Doktoratskolleg, Vienna, Austria, 29.11.2010.
"Cold controlled molecules and their dynamics",
Bothe-Kolloquium, MPI for Nuclear Physics, Heidelberg, Germany, 13.10.2010.

C. D. Schröter
"Atomic and molecular fragmentation dynamics in intense FEL radiation",
Int. Conf. on Coherent and Nonlinear Optics / Int. Conf. on Lasers, Applications and Technologies (ICONO/LAT), Kazan, Russia, 23.-26.8.2010.

J. Schulz
"Ultrafast imaging at FEL light sources",
Meeting of the Finnish Society of Synchrotron Radiation Users, Oulu, Finland, 14.10.2010.
"Diffractive imaging at FLASH",
Peak Brightness Collaboration, HASYLAB, DESY, Hamburg, Germany, 29.9.2010.
"Coherent diffractive imaging at LCLS",
41st DAMOP, Houston, TX, USA, 25.-29.5.2010.
"Femto-Sekunden Röntgenbeugung biologischer Proben an Freie-Elektronen Lasern",
SNI 2010, Berlin, Germany, 24.-26.2.2010.

L. Strüder
"Eine neue Generation von Röntgendetektoren - vom stickstofffreien Silizium Drift Detektor zur Röntgenfarbkamera",
Festkolloquium zum 75. Geburtstag von Prof. Dr. Norbert Langhoff, WISTA Conf. Center, Berlin, Germany, 28.10.2010.
"Semiconductor radiation detectors - in heaven and on earth",
Kolloquiumsvortrag zur Emeritierung von Prof. Dr. Robert Klanner, University of Hamburg, Hamburg, Germany, 19.10.2010.
"Detectors for the experiments at FLASH, LCLS, SCSS and XFEL - the fine art of high speed X-ray imaging",
Physics Department, TUM, Garching, Germany, 5.10.2010.
"Nanometer resolution on a femtosecond scale",
IMC17, Rio de Janeiro, Brazil, 19.-24.9.2010.
"Nanometer resolution on a femtosecond scale",
Microscopy & Microanalysis 2010, Portland, OE, USA, 1.-5.8.2010.
"Detectors for imaging, timing and spectroscopy - in heaven and on earth",
Marshall Space Flight Center, Huntsville, AL, USA, 3.8.2010.
"First light on the CFEL ASG X-ray imaging pnCCD detectors",
55th Annual SPIE Meeting, San Diego, CA, USA, 28.6.2010.

"Nanometer resolution on a femtosecond scale",
EXRS 2010, Figuero da Roz, Portugal, 20.-25.6.2010.
"Erste Streuexperimente am Röntgen FEL in Stanford",
Colloquia, University of Siegen, Siegen, Germany, 10.6.2010.
"Research and development at the MPI semiconductor laboratory",
MPE Fachbeirat, Garching, Germany, 07.6.2010.
"First X-ray imaging experiments at the LCLS at SLAC",
SORMA 2010, Ann Arbor, MI, USA, 24.-28.5.2010.
"Forschung und Entwicklung am MPI Halbleiterlabor",
MPA-MPE Kuratoriumssitzung, Garching, Germany, 5.3.2010.
"Tracking and imaging detectors - in heaven and on earth",
DESY, Hamburg, Germany, 19.2.2010.
"CAMP first results - imaging spectroscopy with pnCCDs, SDDs and DePFETs",
PSI, Villigen, Switzerland, 29.1.2010.

S. Techert
"Probing chemistry with FELs?",
Int. Focus Workshop "Molecules under X-ray Pulses", Dresden, Germany, 15.-17.11.2010.
"Structural dynamics of chemical reactions investigated with FEL radiation: from orbitals to molecular machines",
ESRF, Grenoble, France, 20.10.2010.
"Chemical reactions studied with ultrafast X-ray pulses: from orbital movements to molecular machines",
Workshop on Evolution and Control of Complexity, APS, Argonne, IL, USA, 09.-13.10.2010.
"Chemistry - making of molecular movies",
Joint Workshop of the MPG BMS and CPTS Divisions on Research Perspectives with FELs, Reisensburg, Germany, 27.-29.9.2010.
"Real-time filming of local and global effects in chemical reactions",
Max Planck Workshop on Biophysics, Uslar, Germany, 13.-14.8.2010.
"FEL science: investigating orbital movements up to molecular machines",
BESSY/HZB, Berlin, Germany, 3.8.2010.
"The study of structures with ultrashort X-ray pulses provided by FELs",
Gordon Research Conf. on Electron Microscopy, El Chicco, Italy, 20.-25.6.2010.
"Strukturdynamik einfacher und komplexer molekularer Prozesse - Grundlagen und Anwendungen",
Universität Leipzig, Leipzig, Germany, 14.4.2010.
"From local to global movements - chemical reactions and molecular switches studied with ultrafast pulsed X-rays",
Ringberg Castle Int. Workshop on "Science with FELs - from first results to future perspectives", Kreuth, Germany, 14.-17.3.2010.
"Time-resolved X-ray methods for probing the structural dynamics in organic solids",
SFB 602 Workshop "Komplexe Strukturen in kondensierter Materie", Mariaspring, Germany, 5.-6.2.2010.
"Liquid crystal dynamics investigated with time-resolved X-ray methods",
SFB 755 Workshop "Nanoscale Photonic Imaging", Drübeck, Germany, 15.-17.1.2010.
"Chemical reactions studied with (ultrafast) X-ray pulses: from orbital movements to molecular machines",
CFEL, Hamburg, Germany, 11.1.2010.

J. Ullrich
"FELs: ultra-brilliant light for science",
FIAS Colloquium, Frankfurt, Germany, 25.11.2010.
"FELs: dynamics and structure towards femtosecond time and nanometer spatial resolution",
Int. Conf. "Dynamics of Systems on the Nanoscale" (DySoN 2010), Rome, Italy, 16.-19.11.2010.
"Brilliant FEL light: new frontiers in atomic and molecular physics",
Int. Symp. on Frontiers in Quantum Photon Science, Hamburg, Germany, 11.-12.11.2010.
"FELs - status and opportunities",
Joint Workshop of the MPG BMS and CPTS Divisions on Research Perspectives with FELs, Reisensburg, Germany, 27.-29.9.2010.
"FELs: ultra-brilliant light for science",
General Physics Colloquium, Aarhus, Denmark, 14.9.2010.
"Time-resolved experiments with FELs: towards the molecular movie?",
KITP Conf. "X-ray Science in the 21st Century", Santa Barbara, CA, USA, 2.-6.8.2010.
"Brilliant FEL light: new frontiers in atomic and molecular physics",
10th European Conf. on Atoms, Molecules and Photons (ECAMP10), Salamanca, Spain, 4.-9.7.2010.
"Atomic and molecular dynamics in the light of next generation sources",
Workshop on Advances in Strong Field and Attosecond Physics, London, United Kingdom, 23.-25.6.2010.
"FELs: ultra-brilliant light for science",
AMQ Colloquium, Heidelberg, Germany, 9.6.2010.
"Brilliant FEL light - new frontiers in AMO research and beyond",
Program Workshop "Nanoworld in Action", Groningen, Netherlands, 7.-8.6.2010.
"Physics with FELs",
5th ITS LEIF Annual Meeting, Porto Conte, Italy, 10.-14.5.2010.
"FELs: ultra-brilliant light for science",
Colloquium, Stockholm, Sweden, 12.4.2010.
"Ultra-brilliant light for science",
Hendrik de Waard Lecture, Groningen, Netherlands, 26.3.2010.
"Molecular dynamics: imaging from within",
DPG Spring Meeting, Hannover, Germany, 8.-12.3.2010.
"Atoms and molecules in intense ultrashort FEL pulses",
31. Arbeitstagung "Energiereiche atomare Stöße", Riezlern, Austria, 1.-4.2.2010.
"Brilliant FEL light: new frontiers in AMO research",
XVIIth Symp. on Atomic, Cluster and Surface Physics (SASP), Obergurgl, Austria, 24.-29.1.2010.
"FELs: ultra-brilliant light for science",
Physics Colloquium, Innsbruck, Austria, 19.1.2010.

T. White
"Femtosecond protein crystallography: online and offline data processing",
LCLS/SSRL Users' Meeting, Data Analysis Workshop, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 17.-21.10.2010.

W. Wurth
"Spectroscopy studies at the SXR beamline at LCLS",
European XFEL SCS Workshop, Trieste, Italy, 16.-17.12.2010.
"Opportunities to study ultrafast dynamics with FLASH",
2nd TUM-HASYLAB Colloquium "The metal-polymer interface", Hamburg, Germany, Nov. 2010.
"Ultrafast dynamics in solids probed and induced by soft X-rays",
KITP Conf. "X-ray Science in the 21st Century", Santa Barbara, CA, USA, 2.-6.8.2010.
"FLASH, the FEL at DESY: machine performance and recent highlights from User experiments",
APS march meeting, Portland, OR, USA 15.-19.3.2010.

B. Ziaja-Motyka
"Ultrafast dynamics within complex systems",
CFEL, Hamburg, Germany, 14.9.2010.
"Kinetic equation approach to describe dynamics of irradiated samples",
KITP Conf. "X-ray Science in the 21st Century", Santa Barbara, CA, USA, 2.-6.8.2010.
"Kinetic equation approach to describe dynamics of irradiated samples",
Physics Department, Goethe University Frankfurt, Frankfurt, Germany, 16.7.2010.
"Kinetic equation approach to describe dynamics of irradiated samples",
GSI, Darmstadt, Germany, 22.6.2010.
"Kinetic equation approach to describe dynamics of irradiated samples",
SNI 2010, Berlin, Germany, 24.-26.2.2010.
"Interaction of VUV and soft X-ray free-electron radiation with matter",
Int. Workshop on X-ray Diagnostics and Scient. Appl. of the European XFEL, Ryn, Poland, 14.-17.2.2010.
"Dynamics within atomic clusters irradiated with VUV and soft X-ray radiation",
30th Int. Workshop on Physics of High Energy Density in Matter, Hirschegg, Austria, 1.-5.2.2010.

2009

V. Averbukh
"Intra- and inter-atomic decay processes in multiply ionized clusters",
Int. Workshop "Atomic Physics", Dresden, Germany, 23.-27.11.2009.
"Electronic decay processes in highly charged environment",
Focus Workshop "Key experiments with X-ray pulses from the perspective of theory", Dresden, Germany, 10.-12.9.2009.

C. Beilmann
"HI-light - highly charged ions in the ultra-brilliant light of the LCLS",
LCLS/SSRL Annual Users' Meeting & Workshop on LCLS beam line for soft X-Ray Science, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 19.-23.10.2009.

A. Cavalleri
"Light control in strongly correlated electron systems",
Emerging Themes in Condensed Matter Physics, Aspen, CO, USA, 10.-17.1.2009.
"Light control in solids",
University of British Columbia-Max Planck Workshop, MPI for Solid State Research, Stuttgart, Germany, 16.-18.2.2009.
"Controlling complex solids with light",
Korrelationstage, Dresden, Germany, 2.-3.3.2009.
"Controlling solids with light",
AIST meeting, Okinawa, Japan, 4.-8.3.2009.
"Opportunities for condensed matter physics with new light sources",
New Light Source Launch, Royal Society of London, London, UK, 24.4.2009.
"Controlling solids with light",
Condensed Matter Physics Seminar, UCSD, San Diego, CA, USA, 11.5.2009.
"Light control in solids",
ALS, LBNL, Berkeley, CA, USA, 12.5.2009.
"Light control in solids",
IBM Research Laboratories, San Jose, CA, USA, 13.5.2009.
"Opportunities for condensed matter physics with an infrared FEL",
FEL Symposium, Jefferson Lab, Newport News, VA, US 23.7.2009.
"Dynamics in Mott insulators",
MaNEP meeting, Les Diablerets, Switzerland, 26.-28.8.2009.
"Coherent many body dynamics in Mott insulators",
Orbital Workshop, HZB, Berlin, Germany, 6.-8.10.2009.
"Controlling solids with light",
Colloquium, MPI for Quantum Optics, Garching, Germany, 17.11.2009.

H. N. Chapman
"Ultrafast X-ray imaging with X-ray FELs",
ALS, Berkeley, USA, 4.12.2009.
"Ultrafast X-ray imaging with X-ray FELs",
MRS Fall Meeting, Boston, USA, 30.11.-3.12.2009.
"Coherent imaging",
LCLS/SSRL Annual Users' Meeting & Workshop, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 20.-22.10.2009.
"Ptychography",
Workshop on Developments in Coherent X-ray Methods, University of Melbourne, Melbourne, Australia, 2.-4.10.2009.
"Imaging molecules with X-ray FELs",
10th Int. Conf. on Synchrotron Radiation Instrumentation (SRI2009), Melbourne, Australia, 27.9-2.10.2009.
"Prospects for molecular imaging with X-ray FELs",
1st Int. Symp. on Structural Systems Biology, University of Hamburg, Hamburg, Germany, 24.-25.9.2009.
"Flash imaging",
Workshop on new biological imaging possibilities with FELs, University of Cambridge, Cambridge, UK, 15.9.2009.
"Prospects for molecular imaging with X-ray FELs",
Sagamore XVI, Sante Fe, NM, USA, 2.-7.8.2009.
"Time-resolved studies and imaging of biological systems with XUV and X-ray FELs",
Brainstorming meeting on "Perspectives for time-resolved studies and imaging with laser based and FEL photon sources", DESY, Hamburg, Germany 24.-25.6.2009.
"Imaging of non-reproducible cells with single pulses",
Int. workshop on the SCS endstation of the European XFEL, PSI, Villigen, Switzerland, 2.-4. 6.2009.
"Coherent imaging with X-ray FELs",
Colloquium, Department of Physics, University of Southampton, Southampton, UK, 29.5.2009.
"Coherent Diffractive Imaging",
AMO Beamtime Preparation Meeting, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 12.-13.3.2009.
"Ultrafast Coherent diffractive imaging at FLASH",
DPG Spring Meeting of the Section AMOP, Hamburg, Germany, 2.-6.3.2009.
"Coherent X-ray Imaging with X-ray FELs",
Colloquium, PSI, Villigen, Switzerland, 20.2.2009.
"Coherent X-ray Imaging with X-ray FELs",
Physics Colloquium, MPI for Metals Research, Stuttgart, Germany, 3.2.2009.

J. Crespo López-Urrutia
"Photonic interactions of highly charged ions with synchrotron and FEL radiation",
Michigan State University, NSCL, East Lansing, MI, USA, 23.10.2009.
"Electron beam ion trap end station",
LCLS/SSRL Annual Users' Meeting & Workshop, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 18.-21.10.2009.
"Interactions of highly charged ions with X-ray photons studied with synchrotrons and FELs",
LBNL, ALS Users' Meeting "Quantum Systems, Clusters and Assembled Materials - From Understanding to Control of Matter", Berkeley, CA, USA, 17.10.2009.
"Nuclear excitations in highly charged ions through electronic transitions",
Int. Workshop on Atomic Effects in Nuclear Excitation and Decay, Trento, Italy, 18.06.2009.
"Photon-ion interactions studied with electron beam ion traps",
3rd Workshop on the physics at EBITS and advanced research light sources (PEARL 2009), Dublin, Ireland, 06.-09.05.2009.
"Laser spectroscopy of highly charged ions using soft X-ray FEL radiation",
Int. Workshop on the Science with and the Instrumentation for Small Quantum Systems at the European XFEL 2009 and "1st IRUVX-PP Annual Meeting", Trieste, Italy, 11.03.2009.
"Soft X-ray laser spectroscopy at FLASH",
HASYLAB Users' Meeting "Research with Synchrotron Radiation and FELs", Hamburg, Germany, 30.01.2009.

A. Dorn
"Controlling double photoionization in lithium",
DPG Spring Meeting, Hamburg, Germany, 2.-6.3.2009.
"FEL studies on a magneto-optically trapped lithium target",
Workshop on Key Experiments with X-ray Pulses (MOLX09), Dresden, Germany, 10.-12.09.2009.

S. W. Epp
"Status, layout, and capabilities of the CAMP chamber",
1st AMO Meeting, SLAC National Accelerator Laboratory, Menlo Park, Stanford, CA, USA, 16.03.2009.
"Spectroscopy of highly charged ions with FELs",
DPG Spring Meeting, Symp.: Ultra-fast Dynamics in FEL Light Pulses, Hamburg, Germany, 2.-6.3.2009.

C. Gnodtke
"Electron dynamics in rare-gas clusters exposed to intense FEL pulses",
CECAM-LighTnet Workshop: Computational Challenges Emerging from Next Generation Light Sources, Hamburg, Germany, 13.-15.10.2009.

Y. Jiang
"Ultra-fast dynamics in atoms and molecules driven by FEL Radiation",
Int. Symp. on (e, 2e), Double Photoionization and Related Topics, Lexington, KY, USA, 31.7.-1.8.2009.

F. Krasniqi
"Imaging oriented molecules with photoelectron holography",
Workshop on Key Experiments with X-ray Pulses (MOLX09), Dresden, Germany, 10.-12.9.2009.

J. Küpper
"Manipulating large molecules Information form the molecular frame",
GDCh Colloquium, University of Regensburg, Regensburg, Germany, 29.6.2009.
"Manipulating the motion of large molecules: translation, rotation, and conformer selection",
Colloquium Eduard-Zintl-Institute, TU Darmstadt, Darmstadt, Germany, 29.4.2009.
"Manipulating the motion of large molecules: translation, rotation, and conformer selection",
Colloquium Physical Chemistry, University of Basel, Basel, Switzerland, 18.2.2009.

R. Moshammer
"Fragmentation dynamics in intense laser fields",
Int. Coincidence Workshop, Kreuth, Germany, 9.-12.12.2009.
"Atoms and molecules in intense XUV Laser pulses",
Int. Workshop on Atomic Physics (ATOM2009), Dresden, Germany, 23.-27.11.2009.
"Atoms and molecules in intense laser fields",
Theorie Colloquium, Martin Luther University Halle, Halle, Germany, 28.10.2009.
"Break-up of molecules and pump-probe experiments",
Workshop on Key Experiments with X-ray Pulses (MOLX09), Dresden, Germany, 10.-12.9.2009.
"Fragmentation of atoms and molecules in intense laser fields",
Laserphysik-Seminar, Friedrich Schiller University Jena, Jena, Germany, 12.6.2009.
"Fragmentation of atoms and molecules in intense FEL light pulses",
Workshop on Studies of Atoms and Molecules with New Light Sources, Aarhus, Denmark, 27.-29.5.2009.
"Der 'inneren' Uhr von Atomen und Molekülen auf der Spur: Experimente mit ultrakurzen Laserpulsen",
Physikalisches Kolloquium, Goethe University Frankfurt, Frankfurt, Germany, 14.1.2009.

J. M. Rost
"Photo activated Coulomb complexes",
Workshop "The Future of Ultrafast Soft X-ray Science", Berekeley, CA, USA, 30.11.-3.12.2009.
"Massive electron inversion: (ultra)fast electron dynamics in extended systems",
Attosecond Physics 2009, Manhattan, NY, USA, 28.7.-2.8.2009.
"Ultrafast electronic processes in clusters",
Conf. "Ultrafast Dynamic Imaging of Matter", Ischia, Italy, 30.4.-3.5.2009.
"Ultrafast dynamics in finite atomic systems",
APS Spring Meeting, DAMOP09, Charlottesville, VA, USA, 19.-23.5.2009.

A. Rudenko
"Multiphoton reactions in atoms, pump-probe experiments on clusters",
Workshop on Key Experiments with X-ray Pulses (MOLX09), Dresden, Germany, 10.-12.9.2009.
"Few-electron dynamics in intense short XUV pulses",
41st EGAS (European Group on Atomic Systems) Conf., Gdansk, Poland, 08.-11.7.2009.
"Tracing few-particle dynamics in ultrafast laser-matter interactions",
Advanced Light Sources (ADLIS) Seminar, Vienna University of Technology, Vienna, Austria, 26.6.2009.
"Atoms and molecules in intense FEL radiation",
DPG Spring Meeting, Symp.: Ultra-fast Dynamics in FEL Light Pulses, Hamburg, Germany, 2.-6.3.2009.

U. Saalmann
"Fast electron migration in finite systems exposed to intense attosecond and XFEL pulses",
Frontiers in Optics 2009 & Laser Science XXV, San Jose, CA, USA, 11.-15.10.2009.
"Anomalous ultrafast nanoplasma formation in doped helium droplets",
18th Int. Laser Physics Workshop, Barcelona, Spain, 13.-17.7.2009.

C. D. Schröter
"Atomic and molecular dynamics in intense FEL radiation",
XVI International Conf. on Photonic, Electronic and Atomic Collisions (ICPEAC), Kalamazoo, MI, USA, 22.-28.7.2009.

L. Strüder
"First CAMP results – imaging spectroscopy at LCLS",
SLAC National Accelerator Laboratory, Stanford, USA, 10.12.2009.
"Halbleiterdetektoren – im Himmel und auf Erden",
Colloquium Weierstrass Institute for Applied Analysis and Stochastics, Berlin, Germany, 30.11.2009.
"Single photon imaging",
ESO Detector Workshop, Garching, Germany, 14.10.2009.
"MPI – HLL science projects at the MPI für extraterrestrische Physik",
Project Review, MPI for Physics, Munich, Germany, 1.10.2009.
"pnCCDs for synchrotron applications",
Synchrotron ELETTRA, Trieste, Italy, 18.9.2009.
"High speed X-ray imagers – from the infrared to gamma rays",
Goddard Space Flight Center, Greenbelt, Washington DC, USA, 5.8.2009.
"High speed imaging spectrometers for FLASH, LCLS, SCSS and XFEL",
Gordon Research Conf., Waterville, Maine, USA, 2.-5.8.2009.
"Siliziumdriftdetektoren – Neue Entwicklungen und interessante Anwendungen",
Bruker-AXS Colloquium, Berlin, Germany, 17.6.2009.
"X-ray imaging and spectroscopy techniques",
Imperial College, London, UK, 30.4.2009.
"Detectors for photon science",
ERSF, Grenoble, France, 5.2.2009.
"Detector developments in the MPI Semiconductor Laboratory",
MPG-Riken Conf., MPG Headquarter, Munich, Germany, 22.1.2009.
"pnCCDs for high speed X-ray imaging at X-ray FELs",
European XFEL Detector Advisory Committee Meeting, SIEMENS Conf. Center, Munich, Germany, 2009.

S. Techert
"Structural dynamics of chemical reactions investigated with FEL radiation: from orbitals to molecular machines",
*LCLS/SSRL Annual Users' Meeting & Workshop*s, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 19.-22.10.2009.
"Monitoring real-time chemical dynamics with FEL Radiation",
Int. Bunsen Discussion Meeting "Molecular Transformations and Dynamics in Complex Molecular Environments", Leipzig, Germany, 27.9.-1.10.2009.
"Real-time monitoring of structural switching processes in molecular solids",
European Conf. on Molecular Electronics, Copenhagen, Denmark, 9.-13.9.2009.
"FEL chemistry – towards probing the real-time structural dynamics of water and fast Debye liquids",
FEL Workshop, Copenhagen University, Copenhagen, Denmark, 23.-26.5.2009.
"Monitoring real-time chemical dynamics with FEL radiation",
Totalcryst Workshop, ESRF, Grenoble, France, 1.-3.4.2009.
"Principles and applications of structural dynamics in chemistry",
Institute for Physical Chemistry, Upsalla University, Upsalla, Sweden, 30.3.2009.
"Structural dynamics of chemical reactions. investigated by FEL radiation",
MPG Institutes Seminar, Göttingen, Germany, 30.3.2009.
"FEL science and chemistry",
SFB 755 Workshop "Nanoscale Photonic Imaging", Drübeck, Germany, 19.-21.3.2009.
"Femtosecond X-ray science of chemical systems",
DPG Spring Meeting - AMOP Session, Hamburg, Germany, 2.-6.3.2009.
"Femtosecond X-ray science of chemical systems - progress report",
SFB 602 Workshop "Komplexe Strukturen in kondensierter Materie", Stolberg, Germany, 18.-20.2.2009.
"Structural dynamics in organic solids",
Niels Bohr Institute at Copenhagen University, Copenhagen, Denmark, 14.1.2009.

J. Ullrich
"Super-brilliant FELs: Neues Licht für die Wissenschaft",
DESY Kuratorium, Hamburg, Germany, 3.12.2009.
"Brilliant FEL light: new frontiers in AMO research",
Workshop on The Future of Ultrafast Soft X-ray Science, Berkeley, CA, USA, 30.11.-3.12.2009.
"Electron beam ion trap (EBIT) end station",
LCLS/SSRL Annual Users' Meeting & Workshop on LCLS beam line for soft X-Ray Science, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 19.-23.10.2009.
"Molecular dynamics in the light of next generation sources",
Int. Workshop on Electronic Spectroscopy for Gas-phase Molecules and Solid Surfaces (IWES2009), Matsushima, Japan, 12.-15.10.2009.
"Key experiments with X-ray pulses"
Workshop on Key Experiments with X-ray Pulses (MOLX09), Dresden, Germany, 10.-12.9.2009.
"Brilliant FEL light: new frontiers in AMO physics",
2nd Int. Conference on Attosecond Physics (Atto-2009), Manhattan, KS, USA, 28.7.-1.8.2009.
"Atoms, molecules and clusters in the brilliant light of FELs"
18th Int. Laser Physics Workshop (LPHYS'09), Barcelona, Spain, 13.-17.7.2009.
"Ions and photons: brilliant marriage at FELs",
434. Heraeus-Seminar on "Precision experiments at lowest energies for fundamental tests and constants", Bad Honnef, Germany, 15.-17.6.2009.
"New frontiers in atomic, molecular and optical physics at VUV and X-ray FELs",
3rd Workshop on the physics at EBITS and advanced research light sources (PEARL 2009), Dublin, Ireland, 6.-9.05.2009.

"Sequential and non-sequential ionization in the VUV regime at FLASH",
30. Arbeitstagung Energiereiche Atomare Stöße, Riezlern, Austria, 8.-13.2.2009.
"New frontiers in atomic, molecular and optical physics with FELs",
HASYLAB Users' Meeting, Hamburg, Germany, 30.1.2009.
"Science at XFELs",
1st MPG-RIKEN/ASI Bilateral Conf. on Interdisciplinary Cooperation, Munich, Germany, 21.-23.1.2009.
"Ultra-fast dynamics: pump-probe experiments from the visible to VUV and X-rays",
FU Berlin, Berlin, Germany, 20.1.2009.

W. Wurth
"Challenges and opportunities in surface femtochemistry",
Workshop "The Future of Ultrafast Soft X-ray Science", Berkeley, USA, Dec. 2009.
"Some challenges in surface femtochemistry",
LCLS/SSRL Annual Users' Meeting & Workshop on LCLS beam line for soft X-Ray Science, SLAC National Accelerator Laboratory, Menlo Park, CA, USA, 19.-23.10.2009.
"Spectroscopy with soft X-Ray FELs: opportunities for materials science",
ALS seminar, Berkeley, USA, Oct. 2009.
"Time resolved electronic structure: opportunities with soft X-Rays",
ERL kick-off workshop, HZB Berlin, Mar. 2009.

B. Ziaja-Motyka
"Lasery na swobodnych elektronach-źródla synchrotronowe przyszłości",
Polish Physical Society, Krakow, Poland, 19.11.2009.
"Kinetic equation approach to describe dynamics of irradiated samples",
CECAM Workshop, DESY, Hamburg, 13.-15.10.2009.
"Dynamics within atomic clusters irradiated with VUV and soft X-ray radiation"
1st Porto Workshop on Sources of Super-Intense and Ultrashort Laser Pulses", Porto, Portugal, 26.-28.10.2009.

TALKS AT CFEL

14.12.2010 A. Cavalieri:
“Attosecond spectroscopy at CFEL”.
08.12.2010 F. Capotondi:
“Coherent diffraction imaging at FERMI@ELETTRA”.
01.12.2010 J. Meinen:
“TRAPS: new laboratory techniques for the investigation of nanoparticles with atmospheric relevance”.
29.11.2010 M. Patanen:
“Electron spectroscopic studies of the electronic structure of atoms and molecules”.
29.11.2010 J. W. Freeland:
“Understanding and controlling phases of complex oxides”.
23.11.2010 L. Holmegaard:
“Laser induced alignment and orientation: photoelectron angular distributions from strong field ionization”.
22.11.2010 E. Bettelheim:
“Multi-gapped states in BCS superconductors”.
22.11.2010 M. Eckstein:
“Nonequilibrium dynamical mean-field theory”.
22.11.2010 M. Nest:
“Correlated many electron dynamics from first principles”.
22.11.2010 J. C. Tremblay:
“Laser control of quantum dynamics in dissipative systems”.
29.10.2010 A. Sytcheva:
“Part 1: J-matrix method - a tool for scattering calculations”,
“Part 2: Ultrasound measurements in high magnetic fields”.
22.10.2010 Y.-P. Chang:
“Applications of Zeeman quantum beat spectroscopy to angular momentum polarization studies”.
22.10.2010 D. Dimitrovski:
“Inclusion of static Stark shifts in models for strong-field ionization”.
19.10.2010 Z. Jurek:
“The effects of radiation damage on single molecule imaging at XFEL - model and results”.
15.10.2010 M. Krause:
“Stimulated Raman scattering in silicon photonics”.
08.10.2010 C. Fortmann:
“Dynamical structure factor for dense plasmas: theory and application to X-ray scattering for dense plasma diagnostics”.
30.09.2010 M. Mitrano:
“X-Ray diffraction at high pressures in $V_{1-x}Cr_xO_2$”.
23.09.2010 L. Wansbeek:
“One single trapped radium ion and the standard model of particle physics”.
23.09.2010 A. V. Rode:
“Trapping, manipulation, and transport of particles in air with optical vortices”.
23.09.2010 A. V. Rode:
“Super-dense bcc-Al formed by ultrafast laser microexplosion”.
22.09.2010 H. Jeschke:
“Explaining and predicting phase transitions using tight binding and ab initio molecular dynamics”.
17.09.2010 M. E.-A. Madjet:
“Optical properties of gold nanoparticles and field enhancements using time-dependent local density approximation”.
14.09.2010 B. Ziaja-Motyka:
“Ultrafast dynamics within complex systems stimulated by intense FEL radiation”.
06.09.2010 R. Mankowsky:
“Characterization of current routes in WS_2 thin films with nm resolution”.
06.09.2010 F. Brizuela:
“Full-field microscopy with XUV laser illumination”.
26.08.2010 G. Dixit:
“Relativistic density functional study of structure and vibrational spectra of uranium methylidene complexes CH_2=UHX (X = F, Cl, Br)”.
13.08.2010 C. Hunt:
“Using point contact spectroscopy (PCS) to probe order parameter symmetry in unconventional superconductors”.
04.08.2010 H. A. Navirian:
“Ferroelastic domain switching and nonthermal melting observed by time-resolved X-ray diffraction”.
30.07.2010 S. Pabst:
“3D laser alignment of asymmetric-top molecules and the reconstruction of their 3D structure via X-ray diffraction”.
23.07.2010 S.-K. Son:
“Theoretical study of strong-field multiphoton ionization of polyatomic molecules: a new time-dependent Voronoi-cell finite difference method”.
20.07.2010 J. Stöhr:
“Ten years after: LCLS, from vision to reality”.
20.07.2010 T. Shintake:
“Ultrafast X-ray science in complex solids”.
16.07.2010 O. V. Romagosa:
“Infrared spectroscopy and dynamics of the protonated water-dimer. Quantum dynamical simulations by the MCTDH method”.
29.06.2010 H. Liu:
“Electronic structures in cuprate and Fe-based superconductors from angle-resolved photoemission spectroscopy”.
29.06.2010 N. Rohringer:
“Creating sub-femtosecond pulses in the X-ray regime, by pumping an atomic inner-shell laser with the LCLS”.
24.06.2010 H. Chibani:
“Nano-optomechanical resonators based on superconducting microwave resonators”.
23.06.2010 S. Loth:
“Measuring the spin relaxation time of individual atoms”.
22.06.2010 R. Merlin:
“Mechanisms for ultrafast optical generation of coherent phonons”.
21.06.2010 R. Merlin:
“Negative refraction and radiationless interference: the quest for the superlens”.
11.06.2010 M. von Zimmermann:
“Charge stripe order in $La_{2-x}Ba_xCuO_4$”.
28.05.2010 L. Gelisio:
“Real-space calculation of powder diffraction patterns on graphics processing units”.
21.05.2010 N. Karpowicz:
“Generation and detection of terahertz waves in gases”.
20.05.2010 W. Hu:
“Iron pnictides: itinerant multi-band systems”.
22.04.2010 K. Rossnagel:
“Why do charge density waves occur in layer compounds?”.
16.04.2010 D. Nicolletti:
“An infrared study of metallic-phase instabilities driven by temperature and doping in superconducting cuprates”.
14.04.2010 N. Mannella:
“Electron itinerancy, orbital symmetry and itinerant spin fluctuations in Fe-based superconductors as revealed by soft X-ray spectroscopies”.
24.03.2010 D. Rolles:
“Correlated electron, ion and fluorescence spectroscopy after X-FEL ionization of atoms and molecules - first results from the CAMP instrument at LCLS”.
23.03.2010 A. Caviglia:
“Electric field control of the ground state of an oxide interface”.
09.02.2010 S. R. Park:
“Many body interactions in electron-doped cuprate HTSCs: a view from ARPES”.
04.02.2010 A. Simoncig:
“Toward time-resolved X-ray magnetic circular dichroism experiments in the femtosecond time domain by circularly polarized HHG Light”.
03.02.2010 J. Birch:
“Improved structural quality of multilayers and superlattices by ion-assisted magnetron sputter deposition”.
27.01.2010 R. Singla:
“Growth and characterization of $YBa_2Cu_3O_7/La_{2/3}Ca_{1/3}MnO_3$ superlattice on NdO terminated $NdGaO_3$ substrate”.
14.01.2010 S. Lupi:
“Low-energy electrodynamics and metal to insulator transitions in strongly correlated materials”.
08.01.2010 E. Gryspeerdt:
“Measuring the Faraday effect in 1% Ho:$LiYF_4$”.
06.01.2010 S. Johnson:
“Femtosecond structural dynamics of non-equilibrium solids studied by X-ray diffraction”.
06.01.2010 J. Küpper:
“Manipulating the motion of large molecules: information from the molecular frame”.
06.01.2010 S. Techert:
“Chemical reactions studied with (ultrafast) X-ray pulses: from orbital movements to molecular machines”.

15.12.2009 F. X. Kärtner:
"From femtosecond timing of X-ray FELS to laser driven X-ray sources".
08.12.2009 J. Küpper:
"Manipulating the motion of large molecules: information from the molecular frame".
08.12.2009 R. Ernstorfer:
"Nuclear and electronic dynamics of solids studied by femtosecond electron diffraction and attosecond spectroscopy ".
08.12.2009 S. Johnson:
"Femtosecond structural dynamics of non-equilibrium solids studied by X-ray diffraction".
08.12.2009 N. Huse:
"Ultrafast X-ray spectroscopy of solution-phase systems".
07.12.2009 D. Argyriou:
"Structural optimization in strongly correlated electron systems: opportunities for state of the art light scattering".
04.12.2009 D. Brida:
"Few-cycle optical pulse generation and application to time resolved spectroscopy".
02.12.2009 A. Pimenov:
"Magnetic and magnetoelectric excitations in multiferroic manganites".
01.12.2009 J. van den Brink:
"The light that resonant inelastic X-ray scattering throws on high Tc cuprates".
19.11.2009 I. Grguras:
"Ultrawideband light waveform synthesis".
18.11.2009 P. Popovich:
"Spectral weight transfer and low-lying excitations in Fe-based superconductors and semimetals".
16.11.2009 S. Nandi:
"Rare-earth magnetism in hexagonal $RMnO_3$ (R=Ho,Dy,Er) multiferroics - an X-ray resonant magnetic scattering study".
13.11.2009 G. Cerullo:
"Tracking primary photoinduced events in biomolecules with tunable few-optical-cycle light pulses".
11.11.2009 D. A. Mazurenko:
"The role of symmetry in dynamics of optically induced phase transitions".
10.11.2009 A. Leitenstorfer:
"Femtosecond nano-optics: handling single electrons and photons on molecular time scales".
20.10.2009 J. Hebling:
"Applications of tilted-pulse-front excitation".
12.10.2009 F. Keilmann:
"Viewing the nanoworld in infrared/THz light".
08.10.2009 H. Fleckenstein:
"STXM at the NSLS - Instrumentation and data analysis".
05.10.2009 A. I. Goldman:
"Magnetism and superconductivity in the iron-arsenides: the peculiar case of $CaFe_2As_2$".
23.09.2009 C. Caleman:
"From ice to water in 5 picoseconds".
23.09.2009 S.-Y. Koshihara:
"Dynamics of cooperative lattice-charge (spin) coupled phenomena induced by fs laser light irradiation studied by 100 ps time-resolved X-ray diffraction".
21.09.2009 J. Mohanty:
"Studying dynamics of potential magnetic nano-systems using soft X-ray scattering".
17.09.2009 D. Basov:
"Nanoscale phase separation and memory effects in correlated transition metal oxides".
10.09.2009 N. Huse:
"Ultrafast soft X-ray spectroscopy in the liquid phase".
10.09.2009 R. Neutze:
"Time resolved structural studies of proteins: what is possible now & in the future?".
02.09.2009 S. Flewett:
"Measurement of the coherent modes of a partially coherent wavefield from intensity data".
27.08.2009 C. Jacobsen:
"X-Ray diffraction microscopy: cell imaging at Stony Brook".
20.08.2009 V. Khanna:
"Ironing superconductivity: an ellipsometry study".
18.08.2009 S. Johnson:
"Using femtosecond X-ray diffraction to study non-equilibrium structural dynamics: coherent and incoherent phonons".
20.07.2009 S. Glenzer:
"X-ray Thomson scattering measurements from dense plasmas".
15.07.2009 A. Aquila:
"Advances in multilayer optics for femtosecond sources".
08.07.2009 M. Möckel:
"Real-time evolution of a quenched Fermi liquid".
26.06.2009 S. Brener:
"New approach to non-equilibrium strongly correlated systems".
23.06.2009 F. X. Kärtner:
"Femtosecond laser technologies for seeded FELs".
09.06.2009 A. Schwagmann:
"Terahertz emission from ErAs: InGaAs superlattices".
04.06.2009 P. Tolédano:
"Theory of magnetic multiferroics".
17.04.2009 M. E. Garcia:
"Theoretical description of laser induced ultrafast structural changes in condensed matter".
24.03.2009 M. Cammarata:
"Tracking structural changes in solution with 100ps time resolved X-ray scattering".
20.03.2009 A. Baltuska:
"Few-cycle, tunable, phase stable: new-generation kHz multi-mJ pulse technology for new challenges".
24.02.2009 V. Elser:
"Constraint algorithms and their use in coherent imaging".
10.02.2009 M. Kollar:
"Theory of time-resolved spectroscopy on correlated electron systems".
06.02.2009 I. Robinson:
"Application of coherent X-ray Diffraction imaging to Domain Structures".
22.01.2009 M. C. Hoffmann:
"High power THz generation and THz nonlinear spectroscopy".

IMPRINT

Publishing
Center for Free-Electron Laser Science
A scientific cooperation between DESY, MPG, and UHH

CFEL Interim Address:
CFEL
c/o DESY, Bldg. 49
Notkestraße 85
22607 Hamburg
Germany
www.cfel.de

Contact
Dr. Ralf Köhn
CFEL Research Coordinator
Phone: +49 (0) 40 8998 – 5785
Fax: +49 (0) 40 8994 – 5785
Email: ralf.koehn@cfel.de
Office: Bldg. 49a, Room 202

Chairman of the CFEL Management Board:
Prof. Dr. Joachim Ullrich
Max Planck Institute for Nuclear Physics
P.O. Box 10 39 80
69029 Heidelberg
Germany
Phone: +49 (0) 6221 516 – 696
Fax: +49 (0) 6221 516 – 604
Email: joachim.ullrich@mpi-hd.mpg.de

Editing
Monika Kaempfe, Jörg M. Harms, Ralf Köhn

Layout and Printing
westwerk.eu, Hamburg

Acknowledgements
We thank all authors and everyone who was helping in the realization of this report, especially Regina Brodowski, Irmtraud Kleine, and Devon Donohue-Bergeler.

Photographs and Graphics
CFEL
DESY
MPG
UHH
hammeskrause architekten
CFEL/Jörg M. Harms
CFEL/Ralf Köhn
DESY/Wiebke Laasch
UHH/Arvid Mentz (RRZ/MCC)
UHH/Dichant
BWF/Markert
University of Konstanz/Maximilian Eichberger
University of Konstanz/Hanjo Schäfer
Rüdiger Nehmzow, Düsseldorf

MAX-PLANCK-GESELLSCHAFT

Universität Hamburg

DER FORSCHUNG | DER LEHRE | DER BILDUNG