O 87: Symposium: Beyond Optical Wavelengths: Time-Resolved Spectroscopy of Surface Dynamics with EUV and XUV Radiation III (Invited Speakers: Christian Spielmann, Matias Bargheer, Philippe Wernet)

Time: Friday 9:30–12:00 Location: HE 101

Invited Talk O 87.1 Fri 9:30 HE 101

Time-resolved x-ray absorption spectroscopy with sub-20fs resolution — •Christian Spielmann — Physikalisches Institut EP1 Universität Würzburg, Würzburg, Germany

The development of reliable femtosecond solid-state laser brought new possibilities into time-resolved spectroscopy. For the first time it became possible monitoring the nuclear motion of molecules, crystal lattices and other out-of-equilibrium structures. However, usually it is very difficult to map the experimental observations to the structural dynamics. Therefore, experimental approaches are needed that can overcome the limitation of optical studies for structural determination, while the high temporal resolution of femtosecond lasers is maintained. Structural techniques such as x-ray diffraction (XRD) or x-ray absorption spectroscopy (XAS) deliver much more direct information about the structure. In this contribution we report on the optimized generation of sub-20fs x-ray pulses via high harmonic generation (HHG) resulting in an extension of the cut-off to nearly 3 keV. The x-ray radiation is intense enough over a broad energy range opening the way to time-resolved EXAFS (extended x-ray absorption fine structure). In a first proof-of principle experiment we followed structural changes in Silicon after excitation with an intense laser pulses. From the subsequent temporal evolution of the absorption spectrum far above the L and K-absorption edge, we gained direct information about the atomic motion. The observed dynamic is in good agreement with previous all-optical measurements.

Invited Talk O 87.2 Fri 10:00 HE 101

Direct observation of lattice dynamics by femtosecond x-ray diffraction — •Matias Bargheer — Institut für Physik, Uni Potsdam, Am Neuen Palais 10, 14469 Potsdam — Max-Born-Institut, Max-Born-Str. 2a, 14489 Berlin

The ultrafast photoinduced lattice dynamics of hybrid nanolayers composed of oxides with perovskite crystal structure is investigated by femtosecond x-ray diffraction, using a laser-based table-top hard-x-ray plasma source. The coupling of the optically excited electrons in metallic layers to optical phonon modes and the directed phonon-phonon coupling to particular modes is unravelled by directly observing the lattice motion in real time with sub-picosecond time resolution and sub-picometer accuracy of the structural information. In particular, the photoassisted ultrafast manipulation of ferroelectric polarization by switching giant strain in the GPa range is demonstrated.

O 87.3 Fri 10:30 HE 101

Toward Imaging Ultrafast Evolution on the Nanoscale — •William Schlotter[1,2], Ramon Rick[2], Andreas Scherz[2], Stefan Eisebitt[3], Christian Günther[3], Wolfgang Eberhardt[3], Olav Hellwig[4], Jan Lüning[5], and Joachim Stöhr[2] — [1]Institut für Experimentalphysik Universität Hamburg, Hamburg, Germany — [2]Stanford Synchrotron Radiation Laboratory, SLAC, Menlo Park, California, USA. — [3]BESSY m.b.H., Berlin, Germany — [4]San Jose Research Center, Hitachi Global Storage Technologies, San Jose, California, USA — [5]LCP-MR Université Pierre et Marie Curie, Paris, France.

Panoramic full field imaging with nanoscale resolution is demonstrated with soft x-ray Fourier transform holography. To extend the effective field of view, multiple regions of interest distributed about the sample are strategically paired with a holographic reference wave. In this way, images of each local region are simultaneously reconstructed without compromising spatial resolution. Using a nanoscale test structure fabricated by focused ion beam lithography we image four local regions on the sample spanning 180 μm with sub 100 nm spatial resolution.

Applying this holographic method to a cross-beam pump probe geometry, a technique is proposed for capturing multiple ultrafast images of a sample with a single x-ray pulse. In a cross-beam experimental geometry temporal phenomena are captured with respect to spatial position, and thus higher spatial resolution translates to faster dynamics. In this way the high spatial resolution and full field capabilities of holography are exploited to encode temporal information in a hologram, which could be recorded with a single pulse.

O 87.4 Fri 10:45 HE 101

Surface High Harmonic Generation: A route to ultra-intense attosecond pulses — •Rainer Hörlein[1,2], Yutaka Nomura[1], Brendan Dromey[3], Paraskevas Tzallas[4], Jens Osterhoff[1], Zsuzsanna Major[1,2], Stefan Karsch[1], Dimitris Charalambidis[4], Matthew Zepf[3], Ferenc Krausz[1,2], and George D. Tsakiris[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München, Am Coulombwall 1, 85748 Garching, Germany — [3]Department of Physics and Astronomy, Queen's University Belfast BT7 1NN, UK — [4]Foundation for Research and Technology Hellas, Institute of Electronic Structure and Laser, Heraklion Crete

High harmonic generation from solid surfaces (SHHG) constitutes a route towards generating very high harmonics (HH) and ultra intense attosecond pulses. In contrast to the generation of high harmonics from gases the SHHG mechanism is not limited in the laser intensity that can be used. On the contrary, the conversion efficiency and harmonic cutoff scale very favorably with driving laser intensity.

We present recent experimental results on the generation and characterization of HH radiation from solid targets. We present, amongst others, the generation of diffraction limited harmonic beams at 40nm and show our progress towards the temporal characterization of HHs from surfaces.

We also present an outlook towards possible applications of surface HHs as ultra-intense attosecond XUV probe beams for experiments.

Invited Talk O 87.5 Fri 11:00 HE 101

Femtosecond photoelectron spectroscopy with high-order laser harmonics at photon energies of above 20 eV — •Philippe Wernet, Kai Godehusen, Jerome Gaudin, Olaf Schwarzkopf, and Wolfgang Eberhardt — BESSY, Albert-Einstein-Strasse 15, D-12489 Berlin, Germany

Both bonding and structure of matter change at the atomic level and on ultrafast time scales during chemical reactions. The combination of x-ray spectroscopy, linking electronic and geometric structures, with the recently available short-pulse x-ray sources promises unprecedented access to the ultrafast dynamics in matter. We use high-order harmonics of a femtosecond (fs) laser as a source of fs vacuum ultra violet (VUV) pulses for time-resolved photoelectron spectroscopy. With a stable, reliable source for spectroscopy in mind different ways of generation, monochromatization and focussing of fs VUV pulses will be discussed. Our recent results on the electronic structure of gas phase Br_2 during dissociation will be used as a benchmark test. Laser pulses (400 nm) were used to excite the molecules to a dissociative state and the delayed VUV (53 nm wavelength) probe pulses ionized the molecules (overall temporal resolution 140 fs). Changes of the valence band spectrum indicate ultrafast breaking of the chemical bonds and rearrangements of the valence electronic structure are monitored all the way from the excited molecules into separate atoms.

O 87.6 Fri 11:30 HE 101

Structure and Dynamics of Free Nanoparticles studied by XUV Radiation — •Eckart Rühl — Physikalische und Theoretische Chemie, Freie Universität Berlin, Takustr. 3, 14195 Berlin, Germany

Recent progress on experiments using free nanoparticles is reviewed, where the perspectives on ultrafast processes are focus of the presentation. The targets come preferentially from colloidal chemistry approaches that allow one the preparation of structured nanoscopic objects of well-defined size-dependent properties. These nanoparticles are transferred from the liquid phase via an aerodynamically focused nanoparticle beam into a high vacuum surroundings, where the structural and dynamical properties of single nanoparticles are probed. This approach is complementary to studies on single, trapped nanoparticles. Results and perspectives involving XUV sources, such as synchrotron radiation, free electron laser radiation, as well as short pulse lasers in combination with higher harmonics and laser-produced plasma radiation are discussed along with proper detection techniques, including

velocity map imaging of photoelectrons and elastic light scattering. Perspectives on attosecond dynamics involving free nanoparticles are briefly discussed.

O 87.7 Fri 11:45 HE 101

Ultrafast Phase Transitions in Metastable Water Near Liquid Interfaces — •Bernd Abel — Institut fuer Physikalische Chemie, Universitaet Goettingen, Tammannstr. 6, 37077 Goettingen, Germany

Liquid-gas phase transitions in water are an everyday occurrence, however, phase transitions of metastable superheated water are hardly understood so far despite their importance in many technical processes. By using short laser pulses to deposit heat at a rate faster than the thermal expansion rate, it is possible to prepare extreme states of matter at temperatures well above the normal boiling point. Electron spectroscopy for chemical analysis (ESCA) is a powerful tool for the quantitative analysis of the composition and the chemical environment of molecular systems. Employing high harmonics soft X-ray (50 eV) and near infrared femtosecond pulses and liquid water microbeams in vacuum we were able to add the dimension of time to the liquid interface ESCA technique. Tracing time dependent chemical shifts, electron orbitals and *energies of valence electrons in liquid water in time, we have investigated the timescale and molecular signature of laser induced phase transitions of metastable water on a femto- and picosecond timescale. The time-resolved data have been compared and analyzed with quantum chemistry and molecular dynamics calculations.