A 47: Attosecond physics

Time: Thursday 16:30–18:30 Location: BEBEL E42

A 47.1 Thu 16:30 BEBEL E42

A new twist in photoionization time delay — •Gopal Dixit[1], Himadri Chakraborty[2], Mohamed Madjet[3], and Misha Ivanov[1,4] — [1]max Born Institute, Max-Born-Strasse 2A, 12489 Berlin, Germany — [2]Department of Natural Sciences, Northwest Missouri State University, Missouri USA — [3]Qatar Environment and Energy Research Institute, Qatar Foundation Doha, Qatar — [4]Laboratory, Imperial College London, London SW7 2AZ, United Kingdom

A series of provocative experiments and theoretical studies have brought the question of photoionization time delay to the forefront and the issue is still unresolved. In this talk, I will discuss the effects of electron-electron correlations on the valence photoionization time delay in Ar atom and will present our calculated results, which are in excellent agreement with the Lund group experimental results.

After establishing the delayed response of the outgoing electron to the photon as a result of electron correlations in the photoionization of atoms, I will go beyond the prototypical examples, namely the rare gas atoms, and to consider a more interesting and complex system. I will show effects of confinement and electron correlations on the relative time delay between the 3s and 3p photoionization of Ar confined endohedrally inside C60. Particular nuances of the delay process near a resonance and a Cooper minimum have been recognized. Interesting aspects of the time behavior of atomic emissions, when the atom is taken hostage inside a material confinement, will be discussed. In this context, emissions at the spectral region of the confiner*s plasmonic response are of particular interest.

A 47.2 Thu 16:45 BEBEL E42

2D spectral interpretation of time-dependent absorption spectra of transiently-coupled excited atomic states — •Alexander Blättermann, Christian Ott, Andreas Kaldun, Thomas Ding, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We demonstrate a two-dimensional time-domain spectroscopy method to extract amplitude and phase modifications of excited atomic states caused by the interaction with ultrashort laser pulses. The technique is based on the Fourier analysis of the absorption spectrum of perturbed polarization decay [1,2]. The analytical framework of the method reveals how amplitude and phase information can be obtained from measurements, and how interaction pathways can be separated in the two-dimensional spectral representation. We apply the method experimentally to the helium atom, which is excited by attosecond-pulsed extreme ultraviolet light [3,4], to characterize laser-induced couplings of doubly-excited states [5-7].

References:
[1] Joffre M et al., Springer Series in Chem. Phys. 48 223(1988)
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[4] Hentschel M et al., Nature 414 509 (2001)
[5] Lambropoulos P and Zoller P, Phys. Rev. A 24 379 (1981)
[6] Bachau H et al., Phys. Rev. A 34 4785 (1986)
[7] Chu W-C and Lin C D, Phys. Rev. A 85 013409 (2012)

A 47.3 Thu 17:00 BEBEL E42

High-Order Harmonic Spectroscopy with Water Droplets — •Heiko G. Kurz[1,2], Martin Kretschmar[1,2], Tamas Nagy[1], Detlev Ristau[1,2,3], Manfred Lein[2,4], Uwe Morgner[1,2,3], and Milutin Kovacev[1,2] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, Hannover — [2]QUEST, Centre for Quantum Engineering and Space-Time Research, Welfengarten 1, Hannover — [3]Laser Zentrum Hannover e.V., Hollerithallee 8, Hannover — [4]Leibniz Universität Hannover, Institut für theoretische Physik, Appelstrasse 2, Hannover

We report on high-order harmonic generation (HHG) from dense water droplets, where two intense femtosecond laser pulses interact with a micrometer-sized liquid water droplet under vacuum conditions. The first pulse expands the droplet, which performs a transition from the liquid phase into the gas phase. The second pulse is used for HHG, where different density states become accessible by controlling the delay between the two pulses. Information about the density evolution of the target is probed in-situ with the harmonic radiation, and two density regimes can be determined. The first at low density, where the harmonic yield develops according to the phase-matching conditions and a second, where the density of the target is too high and the electronic trajectories are perturbed during their excursion in the continuum by neighboring particles. By controlling the density of the target via the delay, the transition between these two density regimes is observed.

A 47.4 Thu 17:15 BEBEL E42

Signatures of isolated attosecond pulses spanning the water window by few-cycle driven HHG — •Stephan M. Teichmann[1], Francisco Silva[1], Seth L. Cousin[1], Michaël Hemmer[1], and Jens Biegert[1,2] — [1]ICFO, Mediterranean Technology Park, 08860 Castelldefels (Barcelona), Spain — [2]Institució Catalana de Recerca i Estudis Avanats, 08010 Barcelona, Spain

Excellent transmission contrast in the water window between 280 eV and 530 eV can be exploited for high resolution biological imaging. High order harmonic generation (HHG) has been demonstrated as a table-top source for fully coherent X-ray radiation. While isolated attosecond pulses, useful for pump-probe experiments on the time scale of subatomic motion, have been produced with this technique, they have thus far not been generated in the desirable water window.

Here, we present results from ponderomotively scaled HHG using 1.6 cycle, 1.8 μm wavelength pulses at a repetition rate of 1 kHz with stable carrier envelope phase (CEP). We generate harmonic spectra up to 550 eV in helium, thus spanning the entire water window with fully coherent X-rays. Moreover, control over the CEP allows us to drive the HHG process with a well-defined electric field which in turn leads to the production of half-cycle cutoffs. Simulations confirm, for the first time, the production of isolated attosecond transients across the water window up to 530 eV.

A 47.5 Thu 17:30 BEBEL E42

Noncollinear Optical Gating — •Christoph M. Heyl[1], Fernando Brizuela[1], Linnea Rading[1], Piotr Rudawski[1], Byunghoon Kim[1], Samuel Bengtsson[1], Stefanos Carlström[1], Amélie Jarnac[2], Aurelien Houard[2], André Mysyrowicz[2], Per Johnsson[1], Johan Mauritsson[1], Cord L. Arnold[1], and Anne L'Huillier[1] — [1]Department of Physics, Lund University, Sweden — [2]Laboratoire d'Optique Appliquée, École Polytechnique, France

The generation of isolated attosecond pulses via high-order harmonic generation (HHG), a key issue in attosecond science, requires CEP-stable few-cycle laser pulses and advanced gating techniques. Commonly used gating schemes rely on manipulating the driving field in order to confine the extreme ultraviolet (XUV) emission to a single half cycle. Here, a different approach is presented, based on driving HHG in a noncollinear geometry. A noncollinear generation scheme can be used to angularly streak the generated attosecond pulse train, a method, recently introduced in a conceptually different approach by Vincenti *et al.* [1]. The streaking effect gives access to multiple isolated attosecond pulses and can therefore be used to monitor generation dynamics. Our approach constitutes the first gating scheme which allows a direct separation of the generated XUV radiation from the fundamental field and does not require any manipulation of the driving field [2]. It is therefore ideally suited for pump-probe studies in the XUV regime and promises new advances for intra-cavity high-order harmonic generation.

[1] H. Vincenti *et al.*, Phys. Rev. Lett. **108**, 113904 (2012)
[2] C. M. Heyl *et al.*, to be published

A 47.6 Thu 17:45 BEBEL E42

Non-Equilibrium Dynamics Manifested by Fluctuations in a Quantum Many-Body System: Giant Dipole Resonance of Atomic Xenon — •Yi-Jen Chen[1,2], Stefan Pabst[1], and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [2]Department of Physics, University of Hamburg, Hamburg, Germany

For a quantum many-body system driven out of equilibrium, the dynamics of the system is typically characterized by the expectation value of a suitable observable. The purpose of this work is to evaluate the information inaccessible by the dynamics of the average yet contained in the dynamics of the uncertainty. To this end, many-electron atomic xenon is chosen as the model system. Using ultrashort XUV pulses,

we excite the Xe giant dipole resonance, a well-known example among atomic systems where the collective excitation of the electrons in the 4d shell plays a prominent role. The system is numerically propagated with the ab-initio time-dependent configuration-interaction singles method. We calculate the expectation value of a one-body operator, here the total dipole momentum, and the corresponding uncertainty. We point out the new information extracted from the dynamics of the uncertainty, with special attention to electronic correlation and the coherence between different configurations. By turning on and off the interchannel coupling in the simulation, the sensitivity of the uncertainty as a probe for many-body effects is also discussed.

A 47.7 Thu 18:00 BEBEL E42

Ultrafast resonant X-Ray scattering from electron wave packets — •Daria Popova[1,2] and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Notkestrasse 85, D-22607 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, D-22761 Hamburg, Germany

X-ray free electron laser sources enable ultrafast structural studies of matter with angstrom space and (sub-)femtosecond time resolutions. This makes them a promising tool for imaging of electron wave packet dynamics, which usually takes place on time scales ranging attoseconds to femtoseconds. X-ray resonant scattering is an advantageous technique that is an element-specific probe for charge and spin spatial modulations. We concentrate our study on diffraction of resonant hard X-ray radiation from dynamical electron systems. We examine its basic properties by providing several examples of scattering patterns calculated from different types of electronic wave packets. It has been discussed in the literature that a quantum electrodynamics (QED) treatment is necessary for a correct description of non-resonant scattering of ultrashort X-ray pulses from a dynamical electron system. Therefore, we also apply a QED description to treat resonant X-ray scattering, which allows us to take into account both elastic and inelastic processes. We find that scattering patterns also in the resonant case cannot be interpreted in terms of an instantaneous electron density.

A 47.8 Thu 18:15 BEBEL E42

Role of higher order return trajectories in continuum-continuum harmonic generation — •Hossein Ebadi — Structural dynamics of (bio)chemical Systems, MPI-BPC, Am Fassberg 11, 37077 Goettingen, Germany

High harmonic generation has been numerically analyzed. A clear contribution of those quantum orbits with higher order return to the target potential has been observed in the continuum-continuum harmonic generation [1]. This occurs via interference of their associated wave-packets. In the barrier suppression ionization regime, the role of the trajectories with return order higher than one can be dominant at certain intensity. An empirical method [2] has been introduced to estimate the impact of different return order trajectories at certain emission time. [1] M.C. Kohler, C. Ott, P. Raith, R. Heck, I. Schlegel, C.H. Keitel, T. Pfeifer, Phys. Rev. Lett., 105, 203902 (2010). [2] D. Bauer, P. Mulser Phys. Rev. A, 59 , 569 (1999).