A 24: Attosecond physics

Time: Wednesday 14:30–16:30 Location: C/kHS

A 24.1 Wed 14:30 C/kHS

Phase space approach to propagating a quantum wavepacket — •Norio Takemoto[1,2], Asaf Shimshovitz[2], and David J. Tannor[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Weizmann Institute of Science, Rehovot, Israel

We develop a new method to propagate a quantum wavepacket based on a phase space perspective. The method utilizes the periodic von Neumann basis with biorthogonal exchange (pvb basis) [A. Shimshovitz and D.J. Tannor, Phys. Rev. Lett. 109, 070402 (2012)] generated from a lattice of phase space Gaussians for accurate and efficient representation of the wavepacket. We choose a subset of the pvb basis in a time-dependent manner to adapt to the time evolution of the wavepacket in phase space. This subset can be selected with a guide of classical mechanical trajectories. We demonstrate the accuracy and efficiency of the method first in the propagation of an electronic wavepacket in a one-dimensional model of an atom driven by the combined field of an intense, few-cycle infrared laser pulse and an attosecond extreme-ultraviolet laser pulse [N. Takemoto, A. Shimshovitz, and D.J. Tannor, J. Chem. Phys. 137, 011102 (2012)]. As a first step for extension of the method to multi-dimensioanl systems, we show benchmarking results on the coherent state wavepacket on a two-dimensional harmonic potential.

A 24.2 Wed 14:45 C/kHS

Ultrafast Charge Redistribution in Small Halogenated Hydrocarbon Molecules — •Maximilian Hollstein and Daniela Pfannkuche — Jungiusstraße 9, 20355 Hamburg

We investigate theoretically the ultrafast charge redistribution in small halogenated hydrocarbon molecules following the inner-shell photoionization of a halogene site and the subsequent Auger decay of the induced core hole. By consideration of a truncated time-dependent multi-reference configuration interaction expansion of the dicationic valence wavefunction for a description of the valence electron dynamics, we not only determine final charge distributions but we are also able to estimate the timescale on which the charge redistribution process is completed. For iodomethane (CH3I), we found that charge can be redistributed between two atomic sites (the iodine atom and the carbon atom) within a few hundred attoseconds. However, for diiodomethane (CH2I2), where charge is transferred from one iodine atom to the other iodine atom through an additional atomic site, i.e. the central carbon atom, we found that a complete redistribution occurs on a considerable larger timescale (i.e. 10 - 15 fs). Our calculations suggest that this significant increase is related to a weak coupling of the carbon-iodine bonds within the carbon atom.

A 24.3 Wed 15:00 C/kHS

Sub-cycle resolved probe retardation in strong-field pumped dielectrics — •Adrian N Pfeiffer — Institute of Optics and Quantum Electronics, Abbe Center of Photonics, Friedrich Schiller University, Max Wien Platz 1, 07743 Jena, Germany

The ultrafast response of bulk solids to laser pulses in the strong-field regime is currently paving the way for novel applications of attosecond physics. According to theoretical studies, a possible underlying mechanism is that conduction band levels are transiently populated at the crests of the laser pulse, thereby switching the dielectric from an insulator into a conductor and back into an insulator within one optical cycle. Here, an experimental method is presented which delivers time-resolved information about strong-field processes that occur in dielectric solids during one laser cycle. The method is based on the well-known retardation of a probe pulse by a strong pump pulse. A close-to-collinear alignment of pump and probe beams facilitates the detection of sub-cycle dynamics with respect to an absolute time reference given by the interference signal of the pump and probe pulses. Comparing the sub-cycle resolved measurement of the probe delay to a calculation based on a two-band model reveals that the transient conduction band population affects the measurement in a characteristic way. Moreover, the measurement is sensitive to the interband dephasing time and hence delivers information about the coherence behavior of the strong-field induced conductivity.

A 24.4 Wed 15:15 C/kHS

Signatures of nonadiabatic, relativistic effects and tunneling time delay in the photoelectron momentum distributionof tunnel-ionization — •Enderalp Yakaboylu, Michael Klaiber, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg,Germany

We investigate the influence of the nonadiabatic and relativistic effects on the photoelectron momentum distribution in tunnel-ionization using relativistic strong field approximation. The asymptotic momentum distribution for the maximal tunneling probability in a laser field of elliptical polarization is derived. It is shown that the momentum distribution is shifted with respect to the nonrelativistic case along the laser propagation direction due to the relativistic effect, and the radius of the momentum distribution ellipse is increased due to the nonadiabatic effect. The modifications of the asymptotic momentum distribution arise due to the under-the-barrier dynamics [1,2]. Finally, we discuss the effect of tunneling time delay [2,3]. We define a quantum mechanical trajectory and map the time delay between the quasiclassical trajectory and a quantum mechanical one to a longitudinal momentum shift at the tunnel exit.

[1] M. Klaiber, E. Yakaboylu, H. Bauke, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. 110, 153004 (2013). [2] E. Yakaboylu, M. Klaiber, H. Bauke, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. A 88, 063421 (2013). [3] E. Yakaboylu, M. Klaiber, and K. Z. Hatsagortsyan, Phys. Rev. A 88, 063421 (2014).

A 24.5 Wed 15:30 C/kHS

Time delays in the ionization of atoms — •Hongcheng Ni, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany

Time delays during the ionization process of atoms are studied.

A 24.6 Wed 15:45 C/kHS

Scaling attosecond sources in two complementary directions — •Christoph M. Heyl, Piotr Rudawski, Per Johnsson, Linnea Rading, Bastian Manschwetus, Anne Hardt, Chen Guo, Johan Mauritsson, Cord L. Arnold, and Anne L'Huillier — Lund University, Sweden

Extreme ultraviolet (XUV) light sources based on high-order harmonic generation are nowadays used in many laboratories. Based on the demands set by different applications, two complementary XUV source development directions can be identified: Towards high repetition rates as required by experiments involving electron or ion detection and towards high pulse energies, needed for example for nonlinear optics in the extreme ultraviolet as well as for coherent imaging.

In this talk, an overview about status and limitations for both directions is given and a general model allowing the scalability of pulse energy and repetition rate of attosecond sources over many orders of magnitude while maintaining the conversion efficiency into the XUV [1], is discussed. Examples of attosecond beam lines at both extremes are presented. This includes two beam lines at the Lund Laser Center, a 200 kHz OPCPA-based beam line approaching the single attosecond pulse regime [2] and an intense harmonic beam line [3] as well as an attosecond beam line for the European facility ELI-ALPS [4].

[1] C. M. Heyl *et al.*, Journal of Physics B **45**, 074020 (2012)
[2] P. Rudawski *et al.*, submitted for publication
[3] P. Rudawski *et al.*, Rev. of Sci. Instr. **84**, 073103 (2013)
[4] C. M. Heyl *et al.*, Conceptual design report ELI-ALPS (2012)

A 24.7 Wed 16:00 C/kHS

Carrier-envelope phase dependencies in photoelectron spectra of a metal nanotip and a noble gas in focused few-cycle laser pulses — •Dominik Hoff[1], Michael Krüger[2,3], Georg Wachter[4], Lothar Maisenbacher[3], Michael Förster[2], Sebastian Thomas[2], Joachim Burgdörfer[4], A. Max Sayler[1], Gerhard G. Paulus[1], and Peter Hommelhoff[2,3] — [1]Helmholtz Institute Jena and Institute for Optics and Quantum Electronics, Jena, Germany — [2]Department of Physics, University Erlangen-Nuremberg, Germany — [3]and Max Planck Institute of Quantum Optics, Garching, Germany — [4]Vienna University of Technology, Vienna, Austria

In the last years sensitive probes of the carrier-envelope-phase offset

of few-cycle laser pulses have been discovered and developed into high accuracy phase meters. They are based on the re-scattering process of photo-electrons at noble gases like Xe [1] and at nanoscale metal tips [2]. We report on a comparison of the CEP dependence of these two systems which yields insight into the nano-optical response of the tip with attosecond resolution. Further, the nanotip allows for making a quantitative measurement of the behaviour of the carrier-envelope-phase of focused few-cycle laser pulses. These effects are of high interest in the field of nano-optics, plasmonics, attosecond-pulse generation and ultrafast science in general.

[1] T. Wittmann et al., *Nature Physics* **5**, 357 (2009).
[2] M. Krüger, M. Schenk, P. Hommelhoff, *Nature* **475**, 78 (2011).

A 24.8 Wed 16:15 C/kHS

Electronic pertubation during high-order harmonic generation from 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 the spatial movement of the electron during high-order harmonic generation (HHG). In an in-situ pump-probe measurement with micrometer-sized liquid water droplets, the influence of high-density targets onto HHG is studied. By increasing the density of the target towards mean inter-particle distances matching the excursion distance of the electron, a decrease in the signal of the emitted harmonic radiation is observed. This decrease can be attributed to an increase in the probability of a perturbation of the electron on its trajectory in the continuum, which is induced by neighbouring molecules. This approach allows to follow the electronic movement with Ångstrom spatial resolution, and to probe electronic trajectories during HHG.