A 44: Attosecond physics II

Time: Friday 10:30–12:30 Location: V57.05

Invited Talk A 44.1 Fri 10:30 V57.05

Attosecond control and tracing of collective electron dynamics in nanoparticles — •Matthias Kling — Max-Planck Institut für Quantenoptik, Garching, Germany

Collective electron motion can unfold on attosecond time scales in nanoplasmonic systems, as defined by the inverse spectral bandwidth of the plasmonic resonant region. Similarly, in dielectrics or semiconductors, the laser-driven collective motion of electrons can occur on this characteristic time scale. One of the most promising routes to the realization of electronics operating at Petahertz frequencies arises from applying waveform controlled fields to nanoscale systems, where the nanolocalized near-fields enable for ultimate temporal and spatial control of the relevant electron transport processes. We demonstrate the emission and directional control of highly energetic electrons from isolated nanoparticles in few-cycle laser fields with well defined light waveform. Comparison of the obtained electron momentum distributions to results from quasi-classical simulations indicates that the electron acceleration mechanism is based on rescattering in the enhanced near-field of the nanoparticles. Attosecond nanoplasmonic streaking as one of the potential methods to map the near-fields of isolated nanoparticles in the presence of a strong external driving field will be introduced and discussed.

A 44.2 Fri 11:00 V57.05

Trajectory interferences in a semi-infinite gas cell — •Stephan M. Teichmann[1], Dane R. Austin[1], Matteo Clerici[2], Antonio Lotti[3,4], Daniele Faccio[5], Paolo Di Trapani[3], Arnaud Couairon[4], and Jens Biegert[1,6] — [1]ICFO-Institut de Ciencies Fotoniques, Castelldefels (Barcelona), Spain — [2]INRS-EMT, Université du Québec, Varennes, Canada — [3]Università dell'Insurbia,Como, Italy — [4]École Polytechnique, Centre National de la Recherche Scientifique, Palaiseau, France — [5]Heriot-Watt University, Edinburgh, Scotland — [6]ICREA-Institució Catalana de Recerca i Estudis Avançats, Barcelona, Spain

Interferences between different quantum paths in the high harmonic generation (HHG) process offer insight into the interplay between the microscopic and macroscopic responses. Structures in spectrally resolved far-field spectra can be related to quantum path interference (QPI) effects. Here, we study QPI in the very loose focusing regime for the first time in high harmonic radiation generated in a semi-infinite gas cell. We assign the observed structures to interference of trajectories across the transverse plane of the generating field. A simple model based on the stationary phase approximation (SPA) within the strong field approximation (SFA) is used to describe the underlying effects.

A 44.3 Fri 11:15 V57.05

Tracking temporal dynamics along a femtosecond filament — •M. Kretschmar[1], D.S. Steingrube[1], E. Schulz[1], M. Kovacev[1], U. Morgner[1], M.B. Gaarde[2], and A. Couairon[3] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, D-30167 Hannover, Germany; QUEST, Centre for Quantum Engineering and Space-Time Research, Hannover, Germany — [2]Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001, USA; PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, California 94025, USA — [3]Centre de Physique Theorique, Ecole Polytechnique, CNRS, F-91128, Palaiseau, France

Filamentation of femtosecond laser pulses serves as a versatile and fascinating tool for ultrafast phenomena such as few-cycle-pulse and high-order harmonic generation, which are essential steps for the production of attosecond laser pulses. We present a cell design capable of tracking dynamics inside a filament along its propagation direction, enabling detailed studies of the complex temporal and spatial evolution of the fundamental pulse. The localized analysis is done by truncation of the filament with a pressure gradient at variable positions. We report on the temporal pulse dynamics inside the filament observed by measuring the fundamental spectrum [1] and the pulse duration as well as high-order harmonic radiation originating directly from the filament [2].

[1] E Schulz et al., Opt. Express 19, 19495-19507 (2011)
[2] D S Steingrube et al., New J. Phys. 13 043022 (2011)

A 44.4 Fri 11:30 V57.05

Theory of attosecond transient absorption spectroscopy for overlapping pump and probe pulses — •Stefan Pabst[1,2], Arina Sytcheva[1], Adrian Wirth[3], Eleftherios Goulielmakis[3], and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [2]Department of Physics, University of Hamburg, Hamburg, Germany — [3]Max-Planck-Institut für Quantenoptik, Garching, Germany

Attosecond transient absorption spectroscopy has been successfully applied to the measurement of the ion density matrix of strong-field ionized Krypton. In a recent experiment [A. Wirth et al., Science 334, 195 (2011)] it was shown that it is possible to probe the ionization dynamics of Krypton during an ionizing strong-field pulse that lasted approx. 2 fs. The theory of transient absorption has recently been developed [R. Santra et al., PRA 83, 033405 (2011)] for non-overlapping pump and probe pulses. In the case of overlapping pulses, the question remained whether one probes directly the instantaneous hole population or rather some effective population. Here, we present a theory of attosecond transient absorption spectroscopy for overlapping pump and probe pulses. Within the time-dependent configuration-interaction singles (TDCIS) approach, we describe the pump step (strong-field ionization) as well as the probe step (resonant electron excitation) on equal footing. Furthermore, we include propagation effects and detector resolution in our analysis. Our results support the concept that the transient absorption signal can be directly related to the instantaneous hole population even during the ionizing pump pulse.

A 44.5 Fri 11:45 V57.05

Real-time probing of field ionization induced by sub-cycle light transients — •Antoine Moulet[1], Adrian Wirth[1], Mohammed Tharwat Hassan[1], Ivanka Grguraš[1], Justin Gagnon[1], Tran Trung Luu[1], Stefan Pabst[3,4], Robin Santra[3,4], Zeyad Ahmed Alahmed[2], Abdallah Mohammed Azzeer[2], Vladislav Yakovlev[1,5], Volodymyr Pervak[5], Ferenc Krausz[1,5], and Eleftherios Goulielmakis[1] — [1]Max-Planck-Institut für Quantenoptik, Garching, Germany — [2]King Saud University, Riyadh, Kingdom of Saudi Arabia — [3]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [4]Department of Physics, University of Hamburg, Germany — [5]Department für Physik, Ludwig-Maximilians-Universität, Garching, Germany

We present the application of field-synthesized sub-cycle pulses (1) to the strong field ionization of atoms and the triggering of valence electron coherent motion in the generated ions. We use attosecond XUV transient absorption spectroscopy (2) to probe the dynamics.

Because with such pulses strong field ionization of krypton atoms can be confined to a single light crest, it creates a valence electron wavepacket with an unprecedented degree of coherence. Dynamic spectral distortions shed light on the instantaneous polarization of the electronic system by a varying electric field, often referred to as AC-Stark shift.

(1) A. Wirth *et al., Science* **334**, 195 (2011)
(2) E. Goulielmakis *et al., Nature* **466**, 739 (2010)

A 44.6 Fri 12:00 V57.05

Enhanced High-Order Harmonic Generation using dual gas targets — •Christoph M. Heyl, Fernando Brizuela, Piotr Rudawski, Cord Arnold, and Anne L'Huillier — Department of Physics, Lund University, P. O. Box 118, SE-22100 Lund, Sweden

High-order harmonic generation (HHG) in gases is nowadays well established and used for a variety of applications, in particular for the generation of attosecond pulses which give access to ultrafast phenomena in various fields of physics. This highly nonlinear light conversion process suffers, however, from a relatively low conversion efficiency. Several techniques have been implemented in order to enhance the efficiency, based on either improving phase matching or enhancing the single atom response. In this work, we investigate the possibilities of using a dual gas target in order to enhance the single atom response in the second target by driving the HHG process with an intense laser field and a superimposed harmonic field, generated in the first target. We demonstrate a significant enhancement of the harmonic signal (up to an order of magnitude), if an argon cell is placed in front of our low pressure neon cell. A similar effect has been observed earlier

[1,2] involving an interpretation focusing on the role of the high-order harmonic field for controlling the ionization process in the second target. Our experimental results indicate that the enhancement happens due to low order harmonics which are efficiently generated in the first target.
[1] K. Ishikawa *et al.*, Phys. Rev. Lett. **91**, 043002 (2003)
[2] A. Heinrich *et al.*, J. Phys. B. **39**, S275 (2006)

A 44.7 Fri 12:15 V57.05

Fractional High-order Harmonic Combs and Energy Tuning by Split-spectrum Field Synthesis — •Philipp Raith, Christian Ott, Christopher Anderson, Andreas Kaldun, Kristina Meyer, Martin Laux, Yizhu Zhang, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

High-order harmonic generation in argon is experimentally controlled by splitting up a single broadband continuous spectrum into two components and applying a relative time delay. We observe a pronounced energy tuning of the individual harmonics and present an intuitive, quantitative model for explanation: the tuning results from a change of the instantaneous laser frequency at the interference-induced intensity maxima of the driving shaped pulse. Furthermore, we measured combs of fractional (noninteger) high-order harmonics generated by the controlled interference of two attosecond pulse trains with adjustable relative intensity. The noninteger harmonic combs can be fully modulated and are obtained when the driving laser field is shaped such that it forms two intensity maxima with controllable relative intensities. Simulations based on the strong field approximation show excellent agreement with the measurements, thus demonstrating the microscopic (single-atom response) nature of the control mechanism. In total, the attosecond-precision broadband split-spectrum field synthesis provides comprehensive control of high-harmonic generation and a versatile basis for coherent control of electron dynamics in atoms and molecules with tailored attosecond pulses in the extreme ultraviolet region.