A 34: Atoms in Strong Fields I

Time: Friday 11:00–13:00 Location: N 2

Invited Talk A 34.1 Fri 11:00 N 2

3d-Photoelectron Momentum Distributions from Multi-Photon Ionization with Ultra Short Polarization-Shaped Laser Pulses — •Matthias Wollenhaupt — Carl von Ossietzky Universität, 26129 Oldenburg, Germany

We present our experiments on multi-photon ionization of atoms with polarization-shaped femtosecond light pulses. In the first part, we demonstrate the generation of vortex-shaped photoelectron wave packets from resonance enhanced multi photon ionization (REMPI) of atoms with sequences of two time-delayed, counterrotating circularly polarized pulses from a supercontinuum femtosecond laser source. The electron vortices are measured by velocity map imaging (VMI) and reconstructed using tomographic techniques. In the second part, bichromatic polarization-shaped femtosecond laser pulses [1] are employed to manipulate photoelectron momentum distributions. We study REMPI by counterrotating circularly polarized and orthogonally linearly polarized bichromatic scenarios. The reconstructed 3d-photoelectron momentum distributions show different uncommon angular superposition states at different photoelectron energies. The analysis of the photoionization pathways reveals that REMPI by bichromatic polarization-shaped fields relies on the interplay of selection rules and intrapulse frequency mixing of spectral bands with different ellipticity. Finally, we use a bichromatic pump-probe scheme to follow the time evolution of an atomic spin-orbit wave packet observed in the 3d-photoelectron momentum distribution. [1] S. Kerbstadt, L. Englert, T. Bayer and M. Wollenhaupt, J. Mod. Opt., accepted (2016)

A 34.2 Fri 11:30 N 2

Single-beam bichromatic control of resonance-enhanced multi-photon ionization — •Tim Bayer, Stefanie Kerbstadt, Daniela Johannmeyer, and Matthias Wollenhaupt — Carl von Ossietzky Universität Oldenburg, Institut für Physik, Carl-von-Ossietzky-Straße 9-11, 26129 Oldenburg

Coherent control of quantum phenomena is based on the interference of multiple quantum pathways connecting the initial system state with a preselected target channel. Recently, ultrashort bichromatic laser fields have emerged as an efficient tool to steer coherent electron dynamics in, e.g., strong-field ionization of atoms and high harmonic generation. The beauty of bichromatic fields lies in the capability to disentangle different quantum pathways via frequency mixing and selection rules. Here we employ polarization-tailored bichromatic fields from a $4f$ polarization pulse shaper [1] to study resonance-enhanced multi-photon ionization of atoms as a prototype scenario for multi-pathway coherent control. Three-dimensional detection of the photoelectron momentum distribution by photoelectron imaging tomography provides detailed insights into the excitation and ionization dynamics. We present first results of current experiments on potassium atoms using orthogonal linearly and counter-rotating circularly polarized bichromatic fields.

[1] S. Kerbstadt, L. Englert, T. Bayer, M. Wollenhaupt, J. Mod. Opt., accepted (2016)

A 34.3 Fri 11:45 N 2

Velocity Map Imaging and Semi-classical analysis of Scattering Dynamics in Orthogonal Two-color Fields — •Daniel Würzler[1,2], Max Möller[1,2], Nicolas Eicke[3], Daniel Seipt[1,2], Max Sayler[1,2], Stephan Fritzsche[1,2], Manfred Lein[3], and Gerhard G. Paulus[1,2] — [1]Institute of Optics and Quantum-Electronics, Max-Wien-Platz 1, D-07743 Jena, Germany — [2]Helmholtz-Institute Jena, Froebelstieg 3, D-07743 Jena, Germany — [3]Institute for Theoretical Physics, Appelstraße 2, D-30167 Hannover, Germany

Tuning the relative phase of orthogonal two-color laser fields has become an important technique to get insight/control into sub-cycle electron dynamics of strong-field ionization processes. Here this technique is applied to velocity map imaging spectroscopy using an unconventional orientation with the polarization of the ionizing laser field perpendicular to and the steering field parallel to the detector surface. We measure the phase-dependent photoelectron momentum distribution of Neon and Xenon and analyse them by using semi-classical calculations in three dimensions including elastic scattering at different orders of return. The results are confirmed with the solution of three-dimensional time-dependent Schrödinger equation (3D TDSE) calculations. Thereby control over direct and rescattered electrons is demonstrated.

A 34.4 Fri 12:00 N 2

Single-shot characterization of few-cycle pulses based on stereographic above-threshold ionization at 1.8μ**m** — •Philipp Kellner[1], Daniel Adolph[1,2], Danilo Zille[1], Yinyu Zhang[1,2], Philipp Wustelt[1], Daniel Wuerzler[1], Max Moeller[1], A.M. Sayler[1,2], and G.G. Paulus[1,2] — [1]Institute of Optics and Quantum Electronics, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Helmholtz Institute Jena, Froebelstieg 3, 07743 Jena, Germany

The investigation of carrier-envelope (CE-)phase-dependent effects in strong-field laser-matter interaction calls for the precise measurement and control of the time-dependent electric field of few-cycle pulses. For 800 nm center wavelength, stereographic above-threshold ionization (stereo-ATI) in Xenon, i.e., the so-called carrier-envelope phasemeter (CE-phasemeter) is an established technique for a simultaneous, single-shot, real-time measurement of both the CEP and the pulse duration. Here we demonstrate single-shot CEP and pulse length characterisation at 1.8μm with intense few-cycle pulses using stereo-ATI in Xenon and compare it to the results obtained at 800 nm. The demonstrated results open new opportunities in the investigation of CE-phase-dependent processes at shortwave infrared wavelengths.

A 34.5 Fri 12:15 N 2

Laser-subcycle control of sequential double-ionization dynamics of Helium — •Philipp Wustelt[1,2], Max Möller[1,2], Markus S. Schöffler[3], Xinhua Xie[3], Vaclav Hanus[3], A. Max Sayler[1,2], Andrius Baltuska[3], Gerhard G. Paulus[1,2], and Markus Kitzler[3] — [1]Institute of Optics and Quantum Electronics, Friedrich-Schiller-University Jena, D-07743 Jena, Germany — [2]Helmholtz Institute Jena, D-07743 Jena, Germany — [3]Photonics Institute, Technische Universität Wien, Vienna, Austria

We investigate sequential double-ionization of helium by intense close-to-circularly polarized few-cycle laser pulses using a classical trajectory-based model with two independent electrons. Simulated He^{2+} ion momentum distributions are compared to those obtained in recent benchmark experiments [1]. The influence of a number of pulse parameters such as peak intensity, carrier-envelope phase, pulse duration and second- and third-order spectral phase on the shape of the ion momentum distributions is studied. To explain certain fine-scale features observed in the measurement, it becomes important to consider subtle timing-variations in the two-electron emissions introduced by small values of chirp. This result demonstrates the possibility of controlling multi-electron dynamics on the attosecond time-scale by tuning the field-evolution of intense few-cycle laser pulses.

[1] Schöffler et al., Phys. Rev. A **93**, 063421 (2016)

A 34.6 Fri 12:30 N 2

Laser-driven recollisions under the Coulomb barrier — •Thomas Keil[1], Sergey Popruzhenko[2], and Dieter Bauer[1] — [1]Institut für Physik, Universität Rostock, 18051 Rostock, Germany — [2]National Research Nuclear University MEPhI, Kashirskoe shosse 31, 115409, Moscow, Russia

Photoelectron spectra obtained from the *ab initio* solution of the time-dependent Schrödinger equation can be in striking disagreement with predictions by the strong-field approximation (SFA) not only at low energy but also around twice the ponderomotive energy where the transition from the direct to the rescattered electrons is expected. In fact, the relative enhancement of the ionization probability compared to the SFA in this regime can be several orders of magnitude. We show for which laser and target parameters such an enhancement occurs and for which the SFA prediction is qualitatively good. The enhancement is analyzed in terms of the Coulomb-corrected action along analytic quantum orbits in the complex-time plane, taking soft recollisions under the Coulomb barrier into account. These recollisions in complex time and space prevent a separation into sub-barrier motion up to the "tunnel exit" and subsequent classical dynamics. Instead, the entire quantum path up to the detector determines the ionization probability [1].

[1] Th. Keil, S.V. Popruzhenko, D. Bauer, Phys. Rev. Lett. (accepted), preprint arXiv:1608.03844

A 34.7 Fri 12:45 N 2

Intense-field S-Matrix formalism with coulomb interaction applied to ATI — •Willi Paufler[1], Birger Böning[1], and Stephan Fritzsche[1,2] — [1]Friedrich-Schiller-Universität, Jena, Germany — [2]Helmholtz-Institut Jena, Germany

The commonly used Strong-Field Approximation is a powerful tool to study the interaction of few cycle laser pulses with atoms. SFA provides a good insight in many strong-field effects like Above-Threshold Ionization (ATI), Higher Harmonics Generation and Non Sequential Double Ionization. If the SFA is applied to ATI processes, we neglect the influence of the parent ion on the photoelectron and describe it as a free electron in presence of just the laser field. This simplification causes heavy problems in the Low-Energy Structures (LES) and the Keldysh approximation fails to describe this part of the spectrum. We investigate the Strong-field S-Matrix formalism using the continuum Coulomb waves augmented with the time-dependent Volkov phase [1] and compare the calculations with the results of the SFA and TDSE calculations.

[1] Faisal, F. H. M., Phys. Rev. A**94**, 031401 (2016)