A 38: Atoms in Strong Fields II

Time: Friday 14:30–16:30 Location: N 2

A 38.1 Fri 14:30 N 2

Experimental evidence for Wigner's tunneling time — •Nicolas Camus[1], Enderalp Yakaboylu[1,2], Lutz Fechner[1], Michael Klaiber[1], Martin Laux[1], Yonghao Mi[1], Karen Z. Hatsagortsyan[1], Thomas Pfeifer[1], Christoph H. Keitel[1], and Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]IST Austria, Am Campus 1, 3400 Klosterneuburg, Austria

Using a reaction microscope the ionization of atoms in elliptically polarized laser pulses at intensities in the tunneling regime and near-IR wavelength of 1300 nm has been investigated. Applying coincident electron-ion detection in combination with a gas-target that contains a mixture of two species (Argon and Krypton) we succeeded in measuring the 3D electron-momentum distributions for both targets under otherwise exactly identical conditions (same spectrometer settings and pulse parameters). A detailed analysis of even faint differences in the electron spectra for Ar and Kr allow a detailed test of theoretical models and, with the help of theory, a sensitive check of the commonly applied separation of the ionization process (tunneling) and the subsequent electron motion in the laser field (electron streaking). The experimental results will be presented and compared to state-of-the-art calculations for strong-field ionization, including additional effects like e.g. focal volume averaging, target depletion, and others. Finally, consequences in view of the ongoing controversial discussion of tunneling times in strong-field ionization will be highlighted [1]. [1] arXiv preprint arXiv:1611.03701 (2016)

A 38.2 Fri 14:45 N 2

Sequential and Non-Sequential Pathways in the Coulomb Explosion of CH_2IBr — •Katrin Reininger, Felix Schell, Friedrich Freyse, Marc Vrakking, Claus Peter Schulz, and Jochen Mikosch — Max-Born-Institut Berlin

Coulomb explosion induced by a strong laser field has the potential to uncover the positions of nuclei within a molecular system. We studied experimentally the three-body fragmentation dynamics of triply charged CH_2IBr produced by strong-field ionization with intense femtosecond laser pulses. The correlated fragments CH_2^+, Br^+, and I^+ were measured in coincidence in a reaction microscope which allows to obtain their momentum vectors. The dominant pathway observed is Coulomb explosion, where the C-I and the C-Br bonds break simultaneously. A Monte-Carlo reconstruction method is used to derive the geometry of the neutral molecule, which is compared with literature values. Additionally, we observe two weak sequential dissociation pathways: (i) cleavage of the C-I bond followed by fragmentation of CH_2Br^{2+} and (ii) cleavage of the C-Br bond followed by fragmentation of CH_2I^{2+}. Our study encourages the use of Coulomb explosion imaging as a time-resolved probe of molecular dynamics, while cautioning that it is important to understand the details of the fragmentation process.

A 38.3 Fri 15:00 N 2

Photoelectron holography and effects of the core potential — •Nikolay Shvetsov-Shilovski and Manfred Lein — Leibniz Universität Hannover, Hannover, Germany

Strong-field photoelectron holography (SFPH) is a new technique for time-resolved molecular imaging based on the interference of two types of outgoing electron trajectories in strong-field ionization [1]. Different subcycle interference structures were predicted within the semiclassical model accounting for the laser field only [2]. Although this model has provided valuable insight into the SFPH, neglecting the long-range Coulomb potential may be severe.

Using the two-step semiclassical model with interference [3] we investigate the modification of the interference structures due to the Coulomb potential and due to the choice of the initial state. Bearing in mind possible application of the SFPH to negative ions, we study holographic patterns in a short-range potential.

[1] Y. Huismans et al., Science 331, 61 (2011).
[2] X.-B. Bian et al., Phys Rev A 84, 043420 (2011).
[3] N. I. Shvetsov-Shilovski et al., Phys. Rev. A 94, 013415 (2016).

A 38.4 Fri 15:15 N 2

Tunneling exit characteristics from classical backpropagation of an ionized wavepacket — •Hongcheng Ni, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

We study the tunneling exit parameters of single active electron in the helium atom with the recently proposed backpropagation method [Phys. Rev. Lett. **117**, 023002 (2016)] upon different criteria towards defining tunneling ionization. We find, if tunneling ionization is characterized by the emergence of electrons at certain predefined distances from the ion, the tunneling exit parameters extracted have a number of inconsistencies; while if tunneling ionization is defined by a vanishing momentum in the instantaneous field direction, which captures both adiabatic and nonadiabatic tunneling dynamics, the tunneling exit parameters retrieved are intuitive and easy to understand. This analysis has important implications towards future numerical simulations of the attoclock experiments that commonly used trajectory-based methods starting from assumed exit time and position are imprecise. Thereby, we provide a mapping technique that links attoclock experimental observable to the intrinsic tunneling exit time.

A 38.5 Fri 15:30 N 2

Fast Photoelectrons from clusters in Intense IR lasers — •Abraham Camacho Garibay, Ulf Saalmann, and Jan-Michael Rost — MPI-PKS, Dresden

Unlike single atoms where energy absorption occurs either directly through drift momentum (with the characteristic $2U_p$ cutoff) or by single binary collisions ($10U_p$ cutoff), many-particle systems exhibit additional absorption mechanisms. Either by multiple scattering events from different ions or by slingshot effects by the cluster potential, electrons can be emitted above the mentioned cutoffs. Here we simulate the dynamics of Ar clusters in intense IR laser fields, combining Classical Molecular Dynamics simulations with binary Coulombic collisions. Through this scheme, we have been able to observe photoelectrons with surprisingly high energies, in accordance with recent experimental results.

A 38.6 Fri 15:45 N 2

Electron spin filter and polarizer in a standing light wave — •Sven Ahrens — Beijing Computational Science Research Center, Building 9, East Zone, ZPark II, No.10 East Xibeiwang Road, Haidian District, Beijing 100193, China

Electrons can be diffracted in a standing wave of intense light, which has been first discussed by Kapitza and Dirac [1]. Theoretical evidence for electron spin effects has been given for this type of diffraction [2]. In the underlying quantum dynamics one can associate a rotation of the electron spin [3], but nevertheless the final diffraction pattern of such a process is insensitive to the initial spin configuration. Based on a numerical simulation we demonstrate that also spin-dependent diffraction as well as the generation of electron polarization is possible in two-photon Kapitza-Dirac scattering [4]. Furthermore, a refined description of spin-dependent electron diffraction can be deduced from an analytic approximation of the electron quantum state propagation matrix of the process.

[1] P. L. Kapitza and P. A. M. Dirac, Math. Proc. Cambridge Philos. Soc. 29, 297 (1933).
[2] S. Ahrens, H. Bauke, C. H. Keitel and C. Müller, Phys. Rev. Lett. 109, 043601 (2012).
[3] S. Ahrens, H. Bauke, C. H. Keitel and C. Müller, Phys. Rev. A 88, 012115 (2013).
[4] S. Ahrens, arXiv:1604.06201.

A 38.7 Fri 16:00 N 2

Virtual-detector approach to tunneling times in strong-field ionization — •Heiko Bauke, Nicolas Teeny, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Employing a virtual detector [1, 2], a hypothetical device that allows one to monitor the wave function's density with spatial and temporal resolution during the ionization process, it becomes possible to determine probability distributions for the moments when the electron enters and leaves the classically forbidden region from first principles. In this way, a tunneling time in strong-field ionization can be specified. It is shown that neither the moment when the electron most likely enters the tunneling barrier nor when it leaves the tunneling barrier coincides with the moment when the external electric field reaches its maximum. Under the tunneling barrier as well as at the exit the electron has a nonzero velocity in the electric field direction. These results are substantiated by an independent determination of the tunneling time via a quantum clock approach [3], which yields very similar results.

[1] N. Teeny, E. Yakaboylu, H. Bauke, C. H. Keitel, *Phys. Rev. Lett.* **116**, 063003 (2016)

[2] N. Teeny, C. H. Keitel, H. Bauke, *Phys. Rev. A* **94**, 022104 (2016)

[3] N. Teeny, C. H. Keitel, H. Bauke, arXiv:1608.02854 (2016)

A 38.8 Fri 16:15 N 2

Electron vortices in femtosecond multi-photon ionization — •Dominik Pengel, Stefanie Kerbstadt, Daniela Johannmeyer, Lars Englert, Tim Bayer, and Matthias Wollenhaupt — Universität Oldenburg, Institut für Physik, Carl-von-Ossietzky-Straße 9-11, 26129 Oldenburg

We demonstrate the generation of vortex-shaped photoelectron wave packets from multi-photon ionization of potassium atoms with sequences of two time-delayed, counterrotating circularly polarized femtosecond laser pulses. The electron vortices are measured by velocity map imaging spectroscopy and reconstructed using tomographic techniques. Weak-field excitation produces 6-arm Archimedean spirals. A change from c6 to c4 rotational symmetry of the vortices is observed for non-perturbative laser atom interaction. In addition, the influence of the time-delay on the vortex shape is discussed and an outlook towards ultra-broadband excitation using few-cycle pulses is given.