A 19: Interaction with strong or short laser pulses II

Time: Wednesday 14:00–16:15 Location: f107

Invited Talk A 19.1 Wed 14:00 f107

Fragmentation of HeH^+ in strong laser fields — •Florian Oppermann[1], Philipp Wustelt[2], Saurabh Mhatre[3], Stefanie Gräfe[3], Gerhard G. Paulus[2], and Manfred Lein[1] — [1]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, 30167 Hannover, Deutschland — [2]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Deutschland — [3]Institut für Physikalische Chemie, Friedrich-Schiller-Universität Jena, Helmholtzweg 4, 07743 Jena, Deutschland

Our previous study of ionization and double ionization of HeH^+ in strong 800 and 400nm laser pulses has shown the important role of nuclear motion before and during the electron removal [1]. Here we move our focus to laser parameters where both dissociation and ionization are of comparable probability. According to simulations, this implies wavelengths around 1 to 2μm. For fixed molecular orientation the ratio ionization/dissociation can be controlled (sometimes even reversed) via the relative phase in a collinearly polarized ω-2ω laser pulse.

A Keldysh parameter can be defined not only for the ionization of HeH^+ but also for the dissociation process [2]. The ratio of the two Keldysh parameters is roughly 10, i. e. one pathway can be placed in the multi-photon regime while the other one is in the tunneling regime. Thus by changing the two-color delay on a subcycle scale the dominating process can be switched from multi-photon to tunneling and back.

[1] Wustelt et al., Phys. Rev. Lett. 121, 073203 (2018)
[2] Ursrey et al., Phys. Rev. A 85, 023429 (2012)

A 19.2 Wed 14:30 f107

Dynamic quantum state holography — •Kevin Eickhoff[1], Stefanie Kerbstadt[1,2], Tim Bayer[1], and Matthias Wollenhaupt[1] — [1]Carl von Ossietzky Universität Oldenburg, Institut für Physik, Carl-von-Ossietzky-Str. 9-11, 26129 Oldenburg — [2]Center for Free-Electron Laser Science (CFEL), Deutsches Elektronen-Synchrotron DESY, Hamburg

We present a pulse-shaper-based holographic technique for the time-resolved and phase-sensitive observation of ultrafast quantum dynamics. The technique combines bichromatic white light polarization pulse shaping with the tomographic reconstruction of photoelectron wave packets. The physical scheme is based on the interference of a probe wave packet from $(3 + 1)$ resonance-enhanced multiphoton ionization (REMPI) via the target states and a reference wave packet from $(2+1)$ REMPI of the ground state. To create the wave packets, we employ carrier envelope phase (CEP) stable bichromatic $(2\omega : 3\omega)$ pump-probe pulse sequences. The scheme is demonstrated on femtosecond Rydberg wave packet dynamics in potassium atoms using corotating circularly polarized pulse sequences. The interference of continuum states with different angular momenta yields a crescent-shaped photoelectron wave packet rotating in the laser polarization plane due to the interplay of the optical phase and the accumulated quantum phase (Kerbstadt *et al.* Nat. Comm. **10**, 658 (2019)). Access to the photoelectron asymmetry is provided by CEP control of the wave packet's rotation, enabling background-free and time-resolved detection of the crescent's angular motion mapping the bound electron dynamics.

A 19.3 Wed 14:45 f107

Gouy's Phase Anomaly in Electron Waves Produced by Strong-Field Ionization — •Simon Brennecke, Nicolas Eicke, and Manfred Lein — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

Strong-field ionization of atoms in linearly polarized laser fields produces cylindrically symmetric photoelectron momentum distributions that exhibit interference patterns. Here, we solve the long-standing problem that the observed interference fringes could not be fully quantitatively explained in terms of interfering electron trajectories. For a faithful modeling, it is essential to include previously overlooked phase jumps occurring when trajectories pass through focal points. Such phase jumps are known as Gouy's phase anomaly in optics or as Maslov phases in semiclassical theory. When an outgoing wave packet crosses the polarization axis in three dimensions, it is focused due to the rotational symmetry leading to a phase shift of $\pi/2$ (in contrast to the 2D situation). This influences decisively the photoelectron holography fringes. In addition, there exist observable Maslov phases already in two dimensions. Clustering algorithms enable us to implement a semiclassical model with the correct preexponential factor that affects both the weight and the phase of each trajectory. We also derive a simple rule to relate two-dimensional and three-dimensional models.

A 19.4 Wed 15:00 f107

High-harmonic generation in topological graphene-like nanoribbons — •Christoph Jürss and Dieter Bauer — University of Rostock, Germany

The interaction of intense laser-pulses with graphene-like nanoribbons is investigated. The system becomes topological if a (sufficiently large) complex next-nearest neighbor hopping is included. In the topological phase, the ribbon can host edge states, which have no influence on the bulk of the system. The differences between the high-harmonic spectra from finite ribbons and the bulk are studied. These differences indicate the contributions of the edge states to the spectra. Further, the emitted photons show a change in the helicity at a certain energy which depends on the strength of the next-nearest neighbor hopping. This could allow a light source with a controlled helicity of the emitted radiation.

A 19.5 Wed 15:15 f107

Guiding-center motion for electrons in strong laser fields — •Jonathan Dubois[1], Simon Berman[2], Cristel Chandre[3], Turgay Uzer[4], Ulf Saalmann[1], and Jan-Michael Rost[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Strasse 38, 01187 Dresden, Germany — [2]School of Natural Sciences, University of California, Merced, Merced, California 95343, USA — [3]Aix Marseille Univ, CNRS, Centrale Marseille, I2M, Marseille, France — [4]School of Physics, Georgia Institute of Technology, Atlanta, Georgia 30332-0430, USA

The ultimate aim of contemporary ultrashort, ultra strong laser physics is to capture movies of electrons during chemical reactions. Apart from obvious technical difficulties, there has always been a fundamental obstacle to the interpretations of these scans: The motion of an electron in combined laser and electrostatic fields is an unsolved problem. We use a canonical change of coordinates in order to describe the electron motion in terms of its guiding-center. We describe a hierarchy of reduced models for the guiding-center motion based on time averaging of the electron dynamics. We use these reduced models to understand, interpret and assess the electron dynamics and to unravel mechanisms behind nonlinear phenomena observed in experiments.

A 19.6 Wed 15:30 f107

Semiclassical two-step model with quantum input — •Nikolay Shvetsov-Shilovski and Manfred Lein — Leibniz Universität Hannover

Semiclassical models employing classical trajectories are one of the main approaches in strong-field physics. The analysis of the classical trajectories makes it possible to understand the physical picture of the phenomenon under study.

Here we present a semiclassical two-step model with quantum input (SCTSQI) [1]. In the SCTSQI the initial conditions for classical trajectories are determined by the exact quantum dynamics. Therefore, the SCTSQI corrects the inaccuracies of the semiclassical two-step model (SCTS) [2] in description of the tunneling step. We show that for ionization of a one-dimensional atom the SCTSQI model yields quantitative agreement with the numerical solution of the time-dependent Schrödinger equation.

[1] N. I. Shvetsov-Shilovski and M. Lein, Phys. Rev A 100, 053411 (2019).
[2] N. I. Shvetsov-Shilovski, M. Lein, L. B. Madsen et al., Phys. Rev. A 94, 013415 (2016).

A 19.7 Wed 15:45 f107

Under-the-barrier reflections and and time delay in strong field ionization. — •Daniel Bakucz Canário, Michael Klaiber, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We identify the time delay of an ionizing electron wave packet (with respect to the laser peak) in strong field ionization as a phenomenon induced by re-scatterings and interferences of the wavefunction under the Coulomb barrier, corroborating earlier findings relating under-the barrier-scattering to shifts in the momentum probability distribution[1]. We achieve this by separating incoming and outgoing components of the electronic wave function under the barrier, and observing the effect of manually removing the reflected wavefunction components. A simple 1D model of ionization within strong field approximation is considered but the conceptual framework is general. Finally, we compare the calculated electron trajectory after ionization with equivalent adiabatic and classical trajectories and find that, in the regime of small Keldysh parameters, the three trajectories rapidly become indistinguishable, potentially posing challenges for the oft used back propagation method.

[1] M. Klaiber *et al*, Phys. Rev. Lett. **120**, 013201 (2018)

A 19.8 Wed 16:00 f107

Polarization Shaping of High Harmonics generated by structured laser pulses — •Jonas Wätzel and Jamal Berakdar — Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Halle (Saale)

High-order harmonic generation (HHG) from atoms driven by IR vector beams and beams carrying orbital momentum has been demonstrated experimentally [1]. Here we show how a spatiotemporal shaping of the pulse allows to imprint locally circular polarization onto the emitted radiation. As shown analytically and numerically, the time-dependent Stokes parameters, representing the ratio between linear and circular polarization can be controlled by simply tuning the parameters of the IR field. The proposed scheme offers a method for a full polarization control of the emitted HHG by only one input light field.

[1] Carlos Hernández-Garcia et al. "Extreme ultraviolet vector beams driven by infrared lasers", Optica 4, 520-526 (2017)