A 23: Poster – Interaction with Strong or Short Kaser Pulses (joint session A/MO)

Time: Wednesday 17:00–19:00 Location: Tent

A 23.1 Wed 17:00 Tent

Towards Multidimensional XUV Spectroscopy Combined with Spectral Interferometry — •Lina Hedewig[1,2], Carlo Kleine[1], Felix Wieder[1,2], Christian Ott[1,2], and Thomas Pfeifer[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Ruprecht-Karls-Universität Heidelberg, 69120 Heidelberg, Germany

Using up to two infrared (IR) and two extreme ultraviolet (XUV) ultrashort pulses we are currently implementing a method for multidimensional XUV spectroscopy combined with spectral interferometry to gain further insight into gas-phase quantum dynamics of atoms and molecules.

The setup is based on a four-quadrant split-and-delay mirror allowing independent time delay control of each beam. In situ phase correction results in an effective interferometer stability of 1.5 attoseconds. One XUV pulse excites an electronic wave-packet in the target generating a coherent dipole response. This wave-packet is strongfield coupled by the two IR pulses, leading to control of state-specific quantum dynamics as well as the signal's diffraction towards the remaining fourth beam for a nearly background-free detection. To additionally extract the dipole response's phase, the second XUV beam serves as local oscillator for heterodyned spectral interferometry. The additional phase information compared to classical transient absorption opens up a plethora of possibilities like pulse reconstruction beyond the single-atom response, improved robustness against detector intensity noise and dipole reconstruction for short dipole lifetimes.

A 23.2 Wed 17:00 Tent

Universal Behavior of Tunneling Time and Disentangling Tunneling Time and Barrier Time-Delay in Attoclock Experiments — •Ossama Kullie[1] and Igor Ivanov[2] — [1]Theoretical Physics, Department of Mathematics and Natural Science, University of Kassel, Germany — [2]Department of Fundamental and Theoretical Physics, Australian National University, Australia

In a model we showed that the (tunnel-ionization) time-delay measured by the attoclock experiment can be described accurately in adiabatic and nonadiabatic field calibrations. Moreover, the barrier tunneling time-delay itself can be determined from the difference between the time-delay of adiabatic and nonadiabatic tunnel-ionization, showing good agreement with experimental results. What is particularly striking and interesting is that we have shown that the tunneling time exhibits a universal behavior with disentangled contributions. In Addition, we find that the weak measurement limit, the barrier time-delay corresponds to the Larmor-clock time and the interaction time within the barrier. [1] Submitted to J. Phyis. Comm. (2024). [2] Kullie and I. Ivanov, Annals of Physics 464, 169648 (2024). [3] Kullie, Phys. Rev. A 92, 052118 (2015).

A 23.3 Wed 17:00 Tent

Towards Imaging Electron Dynamics in Solids with Attosecond Resolution — •Matthias Meier[1], Martin Reh[1], Yuya Morimoto[2], Francesco Tani[3], and Peter Hommelhoff[1,3,4] — [1]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen — [2]RIKEN Cluster for Pioneering Research (CPR) and RIKEN Center for Advanced Photonics (RAP), Japan — [3]Max Planck Institute for the Science of Light, 91058 Erlangen, Germany — [4]Department Physik, Ludwig-Maximilians-Universität München (LMU), 80799 München

The understanding and precise control of electron dynamics in solids plays a key role for the development of new technologies. However, investigating the time-resolved dynamics on the timescale of femto- to attoseconds proves to be a persistent challenge. One way to overcome this issue is by optically probing the dynamics on the very same timescale. For this aim, isolated attosecond pulses (IAP) present a sharp and distinct measurement tool which is ideally suited to investigate these ultrafast mechanisms. Here, we present the pulse compression of 20μJ pulses at a central wavelength of 1030 nm and a width of 225 fs down to few cycle pulses which are used to generate XUV light by driving a high-harmonic generation process. Adjusting the stabilized carrier-envelope phase together with a short-pass filter allows to generate IAP. Combining the IAP with a copy of the driving field in an ultrashort pump-probe scheme enables the observation of electron dynamics in the attosecond time scale.

A 23.4 Wed 17:00 Tent

Strong-Field Ionization and Laser-Driven Electron Recollision of Molecules studied in a Reaction Microscope — •Narayan Kundu[1], Martin Garro[1], Janko Janko Umbach[1], Horst Rottke[1], Tobias Witting[2], Arne Senftleben[1], and Jochen Mikosch[1] — [1]Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, 34132 Kassel, Germany — [2]Ultrafast XUV-Physics, Max Born Institute (MBI), Max-Born-Straße 2A, 12489 Berlin, Germany

Reaction microscopes (REMIs) are among the most powerful spectrometers in experimental AMO physics. In a REMI, the momentum of multiple electrons and ions resulting from an event can be measured in coincidence. Here we present experiments on isolated molecules, which are ionized with an intense, femtosecond laser field. In current work on Strong-Field Ionization of 1,3-butadiene, n-butane, and 1-butene molecules, we varied intensities and wavelengths. We observe qualitative changes of experimental observables as a function of these parameters, which we interpret as transition between nonsequential and sequential excitation processes in the intense field. We also present our progress towards using Strong-Field Ionization as a probe mechanism for molecular dynamics and on laser-driven elastic rescattering in a chiral molecule. Furthermore, we have set up a post-compression scheme to significantly reduce the pulse duration of the laser pulses from our commercial regenerative amplifier, based on a gas-filled hollow-core fiber with pressure gradient and chirped mirrors.

A 23.5 Wed 17:00 Tent

Electron-nuclear dynamics in dissociative strong-field ionization of D_2 — •Paul Winter and Manfred Lein — Leibniz University Hannover, Germany

In a neutral diatomic molecule, the removal of an electron by a strong field is a much faster process than the subsequent breakup of the ionized molecule, primarily due to the significant difference in mass between the rapidly moving electrons and the considerably heavier nuclei. This mass disparity also suggests that during strong-field ionization with a linearly polarized pulse, the rescattering electron may not significantly affect molecular dynamics. If, however, electrons rescatter inelastically with the core, vibrational excitation could take place [1].

To explore this mechanism, we have developed a non-Born-Oppenheimer model in which we solve the time-dependent Schrödinger equation (TDSE), treating the electron in two dimensions and the internuclear motion in one dimension. Additionally, we have incorporated the first excited state of the ionized molecule to account for typical dissociation phenomena such as bond-softening and above-threshold dissociation (ATD). With this model, we can calculate photoelectron momentum distributions (PMDs) as a function of the kinetic energy release of the nuclei, paving the way for detailed studies of coupled electron-nuclear dynamics.

[1] S. Hell, G.G. Paulus, M. Kübel, private communication

A 23.6 Wed 17:00 Tent

Modeling controlled sub-wavelength plasma formation in dielectrics — •Julia Apportin, Christian Peltz, Björn Kruse, Benjamin Liewehr, and Thomas Fennel — Institute for Physics, Rostock, Germany

Laser induced damage in dielectrics due to short pulse excitation plays a major role in a variety of scientific and industrial applications, such as the preparation of 3D structured evanescently coupled wave-guides [1] or nano-gratings [2]. The corresponding irreversible material modifications predominantly originate from higher order nonlinearities like strong field ionization and plasma formation, which makes their consistent description imperative for any kind of theoretical modelling aiming at improving user control over these modifications. In particular the associated feedback effects on the field propagation can have drastic implications.

We developed and utilized a numerical model, that combines a local description of the plasma dynamics in terms of corresponding rate equations for ionization, collisions and heating with a fully electromagnetic field propagation via the Finite-Difference-Time-Domain

method, adding self-consistent feedback effects like the sudden buildup of plasma mirrors. Here we present recent numerical results regarding the creation and control of sub-wavelength gratings formed at the rear side of pure and gold-coated fused silica films.

[1] L.¯Englert et al, Opt. Express 15, 17855-17862 (2007)
[2] M. Alameer et al, Opt. Lett. 43, 5757-5760 (2018)

A 23.7 Wed 17:00 Tent

Cross-process interference in single-cycle electron emission from nanotips — •Anne Herzig, Thomas Fennel, and Lennart Seiffert — Institute of Physics, University of Rostock, 18059 Rostock, Germany

Photoelectron spectra from strong-field ionization show features like energy cutoffs and interference patterns, influenced by direct and backscattered electrons [1]. The typical cut-offs at $2\,U_p$ and $10\,U_p$ can be explained within the famous three-step model, while quantum inter- and intracycle interferences are typically associated with self-interference of direct or backscattered, respectively [2,3]. However, also cross-process interference (CPI) between direct and backscattered electrons could reveal further insights. To isolate CPI, competing effects from self-interference must be suppressed, achievable with single-cycle laser pulses [4] that confine electron emission to a single optical period. Metallic nanotips further enhance this by restricting electron motion to one half-space, ensuring strong backscattering [5]. Quantum simulations predict CEP-dependent photoelectron spectra with distinct interference patterns. An extended trajectory model confirms these features originate from CPI, offering insights into the underlying physical mechanisms.

[1] F. Krausz et al., Reviews of Modern Physics 81, 163-234 (2009)
[2] F. Lindner et al., Physical Review Letters 95, 040401 (2005)
[3] D.G. Arbó et al., Physical Review A 74, 063407 (2006)
[4] M.T. Hassan et al., Nature 530, 66-70 (2016)
[5] S. Zherebtsov et al., Nature Physics 7, 656-662 (2011)

A 23.8 Wed 17:00 Tent

Pulsed standing waves at 100 MHz repetition rate for multi-photon ionization experiments — •Jan-Hendrik Oelmann, Tobias Heldt, Lennart Guth, Lukas Matt, Thomas Pfeifer, and José R. Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

We investigate multiphoton ionization (MPI) at high laser intensity ($10^{13}\,\mathrm{W/cm^2}$) and high repetition rate (100 MHz) using a novel polarization-insensitive enhancement cavity for amplified near infrared frequency comb laser pulses. A velocity-map imaging (VMI) spectrometer is integrated into the cavity and allows measuring photoelectron angular distributions (PADs) [1]. By turning the laser polarization axis, we were able to tomographically reconstruct 3D PADs from xenon MPI, revealing resonant Rydberg states during ionization [2].

Additionally, the bow-tie cavity supports counter-propagating pulses forming an intense standing wave at the cavity focus. We use the intrinsic nanometric structure of this standing light field to study and control photoemission from a sharp tungsten tip at the nanometer scale [3]. For gas-phase ionization studies, colliding pulses offer the advantage of reducing the interaction volume at the focus and doubling the intensity [4].

[1] J. Nauta *et al.*, Opt. Lett. 45, 2156 (2020). [2] J.-H. Oelmann *et al.*, Rev. Sci. Instrum., 93(12), 123303 (2022). [3] T. Heldt *et al.*, Nanophotonics, 2024. [4] T. Heldt *et al.*, Opt. Lett. 49, 6825-6828 (2024)

A 23.9 Wed 17:00 Tent

High-Harmonics Spectroscopy of Vibrating Chains — •Gabriel Caceres-Aravena and Dieter Bauer — Institute of Physics, University of Rostock, 18051 Rostock, Germany

In this work, we study the High-Harmonic Generation (HHG) of the laser-driven Su-Schrieffer-Heeger (SSH) chain where the electrons are coupled to the local phonons. The electron dynamics is implemented using the tight-binding approximation and the electron-phonon interaction is implemented through the Holstein model, where the local vibrations of ions are approximated to be solutions of the quantum harmonic oscillator. In our simulations we observe that the electrons move accelerated by the electric field from the driving laser, as expected, and also we observe that the phonons move following the electron movement, showing the existence of a polaron. Also, when we introduce phonons to the system, we observe from the eigenenergy spectrum that new states emerge. Transitions to these new states allow for more efficient harmonic generation for certain harmonic orders.

A 23.10 Wed 17:00 Tent

Probing electron dynamics in gases and pulse characterization using an interferometric Velocity Map Imaging setup — •Pranav Sreekumar[1], David Schmitt[1], Sven Fröhlich[1], Uwe Morgner[1], Milutin Kovacev[1], and Andrea Trabattoni[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [2]Center for Free-Electron Laser Science CFEL, DESY Hamburg

The strong-field ionization of rare gases using intense fs laser pulses results in characteristic spectra for photoelectrons in the momentum and energy space. It has been shown that such signatures contain holographic information which can be obtained experimentally with high spatial resolution using a Velocity Map Imaging (VMI) spectrometer for photoelectrons. However, the interpretation of these velocity maps is not straightforward as they often contain signatures arising from multiple phenomena and the isolation of individual signatures is a significant challenge.

In this poster, we will present our setup of an interferometric beamline coupled into a VMI. With our setup, we aim to extract the sub-optical cycle photoelectron holographic signatures, which promises to offer information on electron dynamics within atoms occurring at sub-to-few fs timescales. Besides this, we also demonstrate the capability to perform in-situ pulse characterization, utilizing the higher-order nonlinearity associated with strong-field ionization [1].

[1] Geffert et al., Optics Letters 47.16, 3992-3995 (2022)