A 18: Interaction with Strong or Short Laser Pulses I (joint session A/MO)

Time: Wednesday 14:30–16:15 Location: N 2

Invited Talk A 18.1 Wed 14:30 N 2

Cross-process interference in single-cycle electron emission from metal needle tips — •Anne Herzig[1], Peter Hommelhoff[2], Eleftherios Goulielmakis[1], Thomas Fennel[1], and Lennart Seiffert[1] — [1]Institute of Physics, University of Rostock, 18059 Rostock, Germany — [2]Faculty of Physics, Ludwig Maximilian University Munich, 80799 Munich, and Department of Physics, Friedrich Alexander University Erlangen-Nuremberg, 91058 Erlangen, Germany

Photoelectron spectra from strong-field ionization exhibit energy cutoffs and interference patterns from direct and backscattered electrons. While cutoffs at 2 U_p and 10 U_p follow from the three-step model, observed fringe structures are usually linked to interference within either emission channel. However, cross-process interference (CPI) *between* direct and backscattered electrons remains largely unexplored. With single-cycle pulses limiting emission to one optical cycle [1] and nanotips directing electrons into a single half-space [2], conditions arise under which CPI can be clearly resolved.

In our recent study [3], we predict carrier-envelope-phase-dependent spectra with clear CPI signatures by comparing TDSE simulations with a trajectory model extended by quantum interference. The resulting fringe pattern encodes sub-cycle information on the near-field acceleration dynamics, highlighting CPI as a promising route toward ultrafast solid-state photoemission metrology.

[1] M.T. Hassan et al., Nature 530, 66-70 (2016)
[2] S. Zherebtsov et al., Nature Physics 7, 656-662 (2011)
[3] A. Herzig et al., https://arxiv.org/abs/2509.01524 (2025)

A 18.2 Wed 15:00 N 2

Multiphoton ionization with three-dimensional laser fields — •Hans-Christian Ahlswede, Darius Köhnke, Tim Bayer, and Matthias Wollenhaupt — Carl von Ossietzky Universität Oldenburg

We report the first observation of free-electron angular momentum wave packets generated by atomic multiphoton ionization with bichromatic three-dimensional (3D) polarization-tailored ultrashort laser fields. These fields, created by the non-collinear superposition of two polarization-shaped pulses of different colors from a supercontinuum polarization pulse shaper, provide electric-field components along all spatial directions. The resulting photoelectron momentum distributions, recorded via velocity map imaging, demonstrate full 3D coherent control of electronic superposition states extending beyond the constraints of planar polarization fields by unlocking all dipole selection rules $\Delta m = 0, \pm 1$. As an application, 3D pump*probe fields are used to image previously unobserved photoelectron wave packets mapping spin-orbit dynamics of the potassium $3d$ fine structure doublet. Our shaper-based approach establishes a route to fully controllable 3D light fields for chiral-sensitive light-matter interactions and ultrafast spectroscopy.

A 18.3 Wed 15:15 N 2

Towards a velocity-map-imaging spectrometer for ultracold atoms — •Lasse Paulsen[1], Julian Fiedler[1], Jette Heyer[1], Markus Drescher[1], Klaus Sengstock[1], Klaus Bartschat[2], Juliette Simonet[1], and Philipp Wessels-Staarmann[1] — [1]Center for Optical Quantum Technologies, Universität Hamburg, Hamburg, Germany — [2]Department of Physics and Astronomy, Drake University, Des Moines, USA

The intense electric field of femtosecond laser pulses enables the ultrafast creation of ions and electrons within an ultracold quantum gas. This opens new possibilities for investigating the dynamics of ionic impurities and atom-ion hybrid systems, provided that the kinematics of the ionization process are well understood.

Here we report on the characterization of an electron velocity-map-imaging spectrometer for ultracold quantum gases, as part of a novel coincidence detection unit including an ion microscope. For characterization a pulsed krypton gas jet is ionized by femtosecond laser pulses with a center wavelength of 511 nm and peak intensities around 6×10^{13} W/cm^2. The measured photoelectron momentum distribution is compared to theoretical predictions based on the solution of the time-dependent Schrödinger equation, which confirm the observed significant shifts in the photoelectron energies caused by the high peak intensities.

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A 18.4 Wed 15:30 N 2

Modeling ultrafast plasma formation in dielectrics — •Julia Apportin[1], Christian Peltz[1], Thomas Fennel[1], Misha Ivanov[2], and Anton Husako[2] — [1]Institute for Physics, Rostock, Germany — [2]Max Born Institute, Berlin, 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 modeling. In particular the associated feedback effects on the field propagation can have drastic implications.

We developed a numerical model, that combines a local description of the plasma dynamics in terms of corresponding rate equations for ionization, collisions and heating [3] 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. Considering laser pulses of constant energy (30 nJ), we investigate the influence of pulse duration and focus size on material modification and compare the resulting geometries, energy deposition and critical plasma volume.

[1] L. Englert et al, Opt. Express 15, 17855-17862 (2007)
[2] M. Alameer et al, Opt. Lett. 43, 5757-5760 (2018)
[3] B. Rethfeld, Phys. Rev. B 73 035101 (2006)

A 18.5 Wed 15:45 N 2

Photoinduced transient symmetry breaking and non-linear anomalous Hall responses in centrosymmetric 2D materials — •Arkajyoti Maity, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden

We theoretically investigate the prospect of inducing a non-trivial, nonlinear Hall response in Dirac materials obeying both inversion and time-reversal symmetries, specifically pristine graphene. This is possible by creating a non-thermal electronic distribution in the system by driving it with a finite duration ultrafast sub-cycle laser pulse. The resultant non-equilibrium state, generated by non-adiabatic transitions induced by the laser, can be made to break the general trigonal (C3) symmetry of the Hamiltonian and hence allow for a second-order Hall response to a weak electric probe, closely related to the quantum geometry of the system

A 18.6 Wed 16:00 N 2

High-harmonic generation in an organic molecular crystal — •Falk-Erik Wiechmann[1,2], Samuel Schöpa[1], Lina Marie Bielke[1], Svenja Rindelhardt[1], Serguei Patchkovskii[3], Felipe Morales[3], Maria Richter[3], Dieter Bauer[1,2], and Franziska Fennel[1,2] — [1]Intitute of physics, University of Rostock, 18059 Rostock, Germany — [2]Department of Life, Light and Matter, University of Rostock, 18059 Rostock — [3]Max Born Institute (MBI) for Nonlinear Optics and Short Pulse Spectroscopy, 12489 Berlin, Germany

Recently, organic molecular crystals (OMCs) were introduced as a novel target class for high-harmonic generation (HHG)[1], bridging the gap between gas-phase and solid-state targets. In OMCs, neighboring molecules experience a weak van-der-Waals coupling, which leads to solid like features, e.g. a delocalization of the electronic states over several unit cells. The perfect inherent alignment of all molecules makes OMCs an ideal target class for high-harmonic spectroscopy of large organic molecules, as it avoids the need for extremely challenging alignment techniques that have so far prevented corresponding measurements in the gas phase. With a fundamental 4000 nm mid-IR beam reaching 0.99 TW/cm2 we demonstrate that HHG from Pentacene crystals is possible without imposing physical damage. Measurements of the harmonic yield as a function of the driving polarization direction reveal that the harmonic generation process is driven by intermolecular effects and not by the response of non-interacting aligned molecules.
[1] Wiechmann, FE. et al., Nat. Commun. 16, 9890 (2025)