A 7: Interaction with strong or short laser pulses

Time: Monday 14:00–16:00 Location: S HS 3 Physik

Invited Talk A 7.1 Mon 14:00 S HS 3 Physik
Multielectron polarization effects and ionization of the hydrogen molecule within the semiclassical two-step model — •Nikolay Shvetsov-Shilovski[1], Manfred Lein[1], Lars Madsen[2], and Karoly Tokesi[3] — [1]Leibniz Universität Hannover, Hannover, Germany — [2]Aarhus University, Aarhus, Denmark — [3]Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary

The semiclassical two-step model (SCTS) for strong-field ionization describes quantum interference and accounts for the ionic potential beyond the semiclassical perturbation theory [1]. We extend the SCTS model to take into account multielectron polarization effects [2]. We predict a pronounced narrowing of the longitudinal momentum distributions due to the polarization-induced focusing of photoelectrons. We show that the polarization of the core also modifies interference structures in the photoelectron momentum distributions.

Furthermore, we apply the SCTS model to ionization of the hydrogen molecule. In the simplest case of the molecule oriented along the polarization direction of a linearly polarized field, we predict significant deviations in the electron momentum distributions from the case of atomic hydrogen.

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

[2] N. I. Shvetsov-Shilovski, M. Lein, and L. B. Madsen, Phys. Rev. A 98, 023406 (2018).

A 7.2 Mon 14:30 S HS 3 Physik
Carrier-envelope phase measurement at short-wave infrared wavelengths and Gouy-phase effects in strong-field ionization — •Yinyu Zhang[1,2], Danilo Zille[1,2], Philipp Wustelt[1,2], Dominik Hoff[1,2], Slawomir Skruszewicz[1,2], A. Max Sayler[1,2], and Gerhard G. Paulus[1,2] — [1]Helmholtz Institute, Jena, Germany — [2]Institute of Optics and Quantum Electronics, Jena, Germany

Here, we report on the implementation of a single-shot, real-time, carrier-envelope phase (CEP) measurement based on the measurement of stereographic above-threshold ionization (ATI) at 1.8 μm [1], which is so-called the carrier-envelope phasemeter (CEPM). A specific feature of the CEPM is the ability for simultaneous characterization of the pulse duration. In addition, the CEP dependent stereo-ATI spectra of Xenon at 0.8 μm and 1.8 μm are simulated by using a semi-classical model and 1D-TDSE model. Simulation results for both models show larger CEP-dependence than the measurements for different pulse lengths and this discrepancy increases with decreasing the pulse length. Inspired by the observation of the axial phase shift, known as Gouy phase, or Porras phase (for broadband pulses) [2], such phase shifts are then introduced in the simulation. The new results show a better match with the measurements and it also provides us a more precise calibration for pulse lengths measurement. [1] Y. Zhang et al., Opt. Lett. 42, 5150 (2017). [2] D. Hoff et al., Nat. Phys. 13 947-951 (2017)

A 7.3 Mon 14:45 S HS 3 Physik
Tailored orbital angular momentum in high-order harmonic generation with bicircular Laguerre-Gaussian beams — •Willi Paufler[1], Birger Böning[1], and Stephan Fritzsche[1,2] — [1]Helmholtz Institut Jena — [2]Theoretisch Physikalisches Institut Jena

We report on a method to generate extreme ultraviolet vortices from high-order harmonic generation with two-color counter-rotating Laguerre-Gaussian beams that carry a well-defined orbital angular momentum. Our calculations show that the OAM of each harmonic can be directly controlled by the OAM of the incident LG modes. Furthermore, we show how the incoming LG modes have to be tailored, in order to generate every possible value of OAM in the emitted harmonics. In addition, we analyze the emitted harmonics with respect to their divergence and find that it decreases with the harmonic order and increases with the OAM of the emitted harmonic.

A 7.4 Mon 15:00 S HS 3 Physik
Floquet-Bloch bands in solid-state high harmonic generation — •Lukas Medišauskas, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

High harmonic generation (HHG) in solid state materials is conventionally divided into intra- and inter- band contributions. In time-dependent Schrödinger equation (TDSE) calculations, the inter-band high-harmonic spectra is generally unstructured and fast dephasing times have to be included into the calculation to observe well pronounced harmonic peaks.

We analyse solid state HHG in terms of Floquet-Bloch (FB) bands, i.e., the field-dressed bands in the presence of the laser pulse. We show that the harmonic spectra can be split into a contributions from a single FB band and a contributions between two FB bands. The former consists of clean well pronounced odd harmonics. The latter consists of harmonics at positions depending on crystal momenta. Combining the contributions from the whole Brillouin zone leads to a featureless spectra. Finally, we show that the role of dephasing in TDSE simulations is that of suppressing the noisy inter FB band harmonics and leaving only the clean intra FB band harmonics.

A 7.5 Mon 15:15 S HS 3 Physik
Evidence of Freeman resonances in intense two-color counter-rotating laser fields — •Philipp Stammer[1,2], Felipe Morales[1], Olga Smirnova[1,2], and Misha Ivanov[1,3,4] — [1]Max Born Institut — [2]Technische Universität Berlin — [3]Humboldt Universität Berlin — [4]Imperial College London

We present results of the numerical solution of the TDSE for the Hydrogen atom, and a short range Yukawa potential, exposed to an intense bi-circular laser field. We study the photoelectron angular distributions after strong field ionization.

In the case of the Yukawa potential, we observe a 3-fold symmetry, imposed by the bi-circular field. Additionally we observe many features predicted by SFA for linear fields, including Low Energy Structures due to re-scattered trajectories.

However, when including the Coulomb potential new features appear, and the 3-fold symmetry can be broken. In particular, we focus on the first ATI peak, where a more complex pattern arises. This pattern is born out of the field induced resonant ionization of states shifted by the ponderomotive potential, or Freeman resonances, and could be used to identify the electron dynamics prior to ionization.

A 7.6 Mon 15:30 S HS 3 Physik
Photoelectron holography beyond the electric dipole approximation — •Simon Brennecke and Manfred Lein — Institut für Theoretische Physik, Appelstraße 2, 30167 Hannover, Germany

Photoelectron holography is an ultrafast laser-based imaging technique which produces measurable interference patterns in electron momentum distributions. Its interpretation is usually carried out in electric dipole approximation. However, today's experiments [Phys. Rev. Lett. **113**, 243001 (2014)] are capable of revealing beyond-dipole effects such as a counter-intuitive shift of the momenta into the direction opposite to the laser propagation direction for low electron energies in linearly-polarized fields. We calculate the momentum-dependent shift of the holographic structure by extending the quantum trajectory-based Coulomb-corrected strong-field approximation (CCSFA) beyond the electric dipole approximation. The theory is set up such that in the limit of vanishing potential, it reproduces the beyond-dipole strong-field approximation. The comparison with the numerical solution of the time-dependent Schrödinger equation in 2D and 3D shows that the point of constructive interference between different trajectories describes quantitatively the position of the central maximum in the momentum distribution. Interestingly, this point of constructive interference coincides with the position of the classical ridge due to Coulomb-focusing in 3D [Phys. Rev. A. **97**, 063409 (2018)].

A 7.7 Mon 15:45 S HS 3 Physik
Gaussian-process optimization of photoionization dynamics of many-electron systems — •Yi-Jen Chen[1], Ulf Saalmann[1], Robin Santra[2], and Jan M. Rost[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Center for Free-Electron Laser Science, Hamburg, Germany

Advances in light-source technology have opened up the possibility to manipulate the properties of light and, thus, the possibility to dynamically steer a quantum system in a desired manner. Since the simulation and measurement of light-driven quantum dynamics are costly, for a given control task, the optimal set of laser parameters has to be found as quickly as possible.

In this talk, we present a Bayesian active learning algorithm based on Gaussian-process regression to tackle such optimal control problems. This algorithm converts the search for the optimum of an expensive target function into that of a relatively cheap cost function. As the derivatives of the cost function permit an analytical form, its optimum can be located efficiently using gradient-based optimization schemes.

We apply this algorithm to maximize the degree of coherence of a photoion created by attosecond photoionization. The reduced density matrix of the ionic wave packet, obtained here by ab-initio solution of the N-electron Schrödinger equation, may be probed experimentally using ultrafast spectroscopy. In addition to numerical efficiency, we discuss how to extract physical insights and to select an experimentally accessible maximum by exploiting the global and local information of the target-function landscape.