A 24: Interaction with strong or short laser pulses I

Time: Wednesday 11:00–13:00 Location: f303

A 24.1 Wed 11:00 f303

Strong-Field Breit-Wheeler Pair Production in Short Laser Pulses — •Martin J.A. Jansen and Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Universitätsstr. 1, 40225 Düsseldorf

We study the creation of electron-positron pairs induced by the collision of an intense short laser pulse with a high-energy gamma quantum. Employing detailed S matrix calculations in the framework of laser-dressed quantum electrodynamics, energy spectra of emitted particles are obtained. These spectra reveal a rich structure, which lies in the focus of our present study [1]. Combining concepts known from bichromatic laser fields with the continuous frequency spectrum inherent to the short pulse, an intuitive model is developed which allows to understand the global form of the energy spectra in terms of multiphoton processes. Furthermore, fine structures in the spectra can be traced back to multiphoton interferences which are sensitive to the carrier-envelope phase of the short pulse.

[1] M.J.A. Jansen and C. Müller, arXiv:1511.07660 [hep-ph]

A 24.2 Wed 11:15 f303

Spin effects in high-intensity light-matter interactions — •Heiko Bauke[1], Rico Erhard[1], Anton Wöllert[1], Sven Ahrens[1], Rainer Grobe[2], and Christoph H. Keitel[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Intense Laser Physics Theory Unit and Department of Physics, Illinois State University, Normal, Illinois 61790-4560 USA

Various spin effects are expected to become observable in light-matter interaction at relativistic intensities, in particular if electromagnetic fields with elliptical polarization are involved. It is shown that there is a coupling of the spin angular momentum of light beams with elliptical polarization to the spin degree of freedom of free electrons. This coupling is of similar origin as the well-known spin-orbit coupling and can lead to spin precession [1, 2] as well as spin dynamics in Kapitza-Dirac scattering [3]. Remarkably, these effects are caused by relativistic corrections to the Pauli equation but may be observed even at nonrelativistic intensities. Furthermore, it is demonstrated how the ellipticity of ultra-strong counterpropagating electromagnetic fields affects pair creation and can lead to spin-polarized electron-positron pairs [4].

[1] H. Bauke, S. Ahrens, C. H. Keitel and R. Grobe, New Journal of Physics **16**, 103028 (2014)

[2] H. Bauke, S. Ahrens and R. Grobe, Phys. Rev. A **90**, 052101 (2014)

[3] R. Erhard and H. Bauke, Phys. Rev. A **92**, 042123 (2015)

[4] A. Wöllert, H. Bauke and C. H. Keitel, Phys. Rev. D **91**, 125026 (2015)

A 24.3 Wed 11:30 f303

Photoionization of hydrogen-like ions by twisted attosecond light pulses — •Robert A. Müller[1,2], Daniel Seipt[2], Stephan Fritzsche[1,2], and Andrey Surzhykov[2] — [1]Friedrich-Schiller-University Jena, Germany — [2]Helmholtz-Institute Jena, Germany

In the recent years a number of theoretical studies has been attributed to the interaction between atomic systems and twisted light. It has been found for instance that if an atom is ionized by twisted light, the emission pattern of the photoelectrons remarkably depends on the so called *impact parameter* which is the distance between the target atom and the beam axis [1]. This sensitivity is caused by the spatial inhomogeneity of vortex light beams, which have intensity maxima lying on concentric rings. The loci of these rings depend on the frequency of the twisted light. This frequency has been assumed to be monochromatic in all former studies. Nowadays however it is possible to create twisted pulses in the attosecond regime [2]. Naturally these pulses are not monochromatic but have a frequency distribution. Therefore the beam profiles of the pulses become frequency dependent. In this contribution we discuss how this dependency affects the photoionization of atoms by twisted light. We will present calculations for the angular distribution and the spectrum of the emitted photoelectrons depending on both the impact parameter and the pulse duration which limits the width of the frequency distribution.

[1] Matula *et al.*, J. Phys. B **46**, 205002 (2013)
[2] Géneaux *et al.*, arXiv:1509.07396 (2015)

A 24.4 Wed 11:45 f303

Two-step semiclassical model with quantum interference — •Nikolay Shvetsov-Shilovski[1], Manfred Lein[1], Lars Madsen[2], Esa Räsänen[3], Christoph Lemell[4], Joachim Burgdörfer[4,6], Diego Arbo[5], and Karoly Tőkési[6] — [1]Leibniz Universität Hannover, Hannover, Germany — [2]Aarhus University, Aarhus, Denmark — [3]Tampere University of Technology, Tampere, Finland — [4]Vienna University of Technology, Vienna, Austria — [5]Institute for Astronomy and Space Physics, Buenos Aires, Argentina — [6]Institute of Nuclear Research of the Hungarian Academy of Sciences, Debrecen, Hungary

Trajectory-based semiclassical models are widely used in strong-field physics. A recent quantum trajectory Monte-Carlo (QTMC) approach [1] allows to describe interference effects in above-threshold ionization. The QTMC accounts for the Coulomb potential using the first-order semiclassical perturbation theory.

Here we present a two-step semiclassical model with interference (TSMI) for strong-field ionization [2]. The TSMI accounts for the Coulomb potential beyond the semiclassical pertrubation theory. In TSMI the phase associated with every trajectory is calculated using the matrix element of the semiclassical propagator. By comparison with the numerical solution of the time-dependent Schrödinger equation we show that generally the TSMI describes the interference patterns better than the QTMC.

[1] M. Li et al., Phys. Rev. Lett. 112, 113002 (2014).
[2] N. I. Shvetsov-Shilovski et al., in preparation.

A 24.5 Wed 12:00 f303

Coulomb-corrected complex trajectories in strong-field ionization — •Thomas Keil and Dieter Bauer — Universität Rostock, Institut für Physik

The strong-field approximation (SFA) is known to roughly reproduce photoelectron spectra of atoms in strong laser fields (see [1] for a review). However, there is no $2U_p$ plateau in plain SFA. SFA with rescattering generates a plateau up to $2U_p$ but qualitatively wrong and with an ambiguous dependence on a screening parameter. Simple man's theory (SMT) reproduces the $2U_p$ cutoff-law but gives vanishing probability at the cutoff, and thus no plateau as well.

We show that by applying a Coulomb-correction inspired by [2] to the trajectory-based SFA [3,4] we can reproduce the plateau and cutoff as seen in results obtained by solving the time-dependent Schrödinger equation (TDSE) numerically. This approach uses complex trajectories everywhere and therefore does not require the concept of a "tunnel exit". We compare this method to the plain SFA, the TDSE and a different Coulomb-corrected SFA used in previous works. The generation of the $2U_p$ plateau and cutoff is demonstrated, and the mechanism behind it is analyzed. The problem of branch cuts in the complex-time plane due to the Coulomb potential (as described in [5]) is discussed.

[1] S.V. Popruzhenko, J. Phys. B 47 204001 (2014)
[2] S.V. Popruzhenko, JETP 118, 580 (2014)
[3] T.-M. Yan et al., Phys. Rev. Lett. 105, 253002 (2010)
[4] Th. Keil et al., J. Phys. B 47, 124029 (2014)
[5] E. Pisanty et al., arXiv:1507.00011 [quant-ph]

A 24.6 Wed 12:15 f303

Optical response in femtosecond filaments dominated by resonantly enhanced ionization — •Michael Hofmann[1,2] and Carsten Brée[1,3] — [1]Weierstraß Institut für angewandte Analysis und Stochastik (WIAS) — [2]Institut für theoretische Physik, TU Berlin — [3]Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (MBI)

Although the standard model of femtosecond filamentation is quite successful in many applications, its validity has been under discussion over the last years (initiated by [1]). For example, the employed ionization rate does not account for resonances between laser-dressed states. We show exemplarily for a hydrogen atom that resonances locally enhance the ionization which in turn saturates the nonlinear refractive index [2]. Such a saturation can easily be misinterpreted as a higher-order Kerr effect if resonances are neglected. By modifying the standard model to include resonantly enhanced ionization, we obtain a remarkable agreement between model and TDSE simulations in the adiabatic regime of a slowly varying pulse envelope. Our goal is to go beyond this adiabatic regime and to derive the optical response for arbitrary pulses without the need to solve the time-dependent Schrödinger equation, thus keeping large-scale filament simulations feasible.

[1] Loriot et al., Opt. Express **17** 13429 (2009).
[2] Hofmann and Brée, Phys. Rev. A **92** 013813 (2015).

A 24.7 Wed 12:30 f303

Spatio-temporal dynamics along a femtosecond filament — •Martin Kretschmar[1], Carsten Bree[2], Tamas Nagy[1,3], Heiko Kurz[1], Uwe Morgner[1], and Milutin Kovacev[1] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Hannover — [2]Weierstrass-Institut für angewandte Analysis und Stochastik, Berlin — [3]Laser-Laboratorium Göttingen, Göttingen

Filaments occur as the nonlinear balance between self-focusing due to the Kerr-effect and defocusing due to free electrons generated by ionizing the surrounding medium. As a result, complex spatio-temporal dynamics take place during the filamentation process, which strongly influence the propagating pulse. We report on the direct observation of pulse dynamics along the filament and its connection to directly emitted high-order harmonic radiation. The nonlinear nature of the high-harmonic generation process is used to gain further insight into the fundamental pulses propagation dynamics. Theoretical modeling of the fundamental pulse propagation confirms our experimental observations and gives further insight into the nonlinear dynamics occurring along a filament.

A 24.8 Wed 12:45 f303

Double-slit electron interference in strong-field ionization of neon dimer — •Maksim Kunitski, Pia Huber, Jonas Köhler, Kevin Henrichs, Nikolai Schlott, and Reinhard Dörner — Institut für Kernphysik, Goethe-Universität Frankfurt am Main, Max-von-Laue-Straße 1, D-60438 Frankfurt am Main

The double-slit experiment has been widely utilized in order to learn different aspects of quantum mechanics, as, for instance, in famous Bohr-Einstein debates. In 1960s it was realized that the double-slit experiment can be performed at the molecular level by exploiting two sites of a diatomic molecule as coherent electron emitters [1].

Here we report the observation of photo-electron double-slit interference in single ionization of neon dimer by a strong ultra-short laser field (40 fs, 790 nm, $6.0{\cdot}10^{14}$ W/cm^2). An electron and a single Ne ion resulting from break-up of Ne^{2+} along the repulsive $II(1/2)_g$ potential were measured in coincidence by means of COLd Target Recoil Ion Momentum Spectroscopy (COLTRIMS) [2]. The interference pattern in the angular distribution has been found to be governed by the parity of the molecular orbital from which the electron is freed. The electron removed from an *ungerade* orbital shows constructive interference perpendicular to the molecular axis, whereas the one from a *gerade* orbital shows destructive interference.

[1] H. D. Cohen, U. Fano, Phys Rev 150, 30-33 (1966).
[2] J. Ullrich et al., Rep. Prog. Phys. 66, 1463 (2003).