A 1: Interaction with strong or short laser pulses I

Time: Monday 10:30–12:30 Location: V55.01

Invited Talk A 1.1 Mon 10:30 V55.01

Atoms and ions in intense ultrashort laser pulses: entering the relativistic regime — •Alejandro Saenz — Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

The experimental availability of ultrashort laser pulses with extreme peak intensities above $10^{20}\,\mathrm{W\,cm^{-2}}$ opens an mostly unexplored field of laser-matter interaction. At these intensities the influence of the magnetic field cannot longer be ignored. This demands a treatment beyond the usual non-relativistic description within the dipole approximation. A further reason for abandoning the dipole approximation is that short wavelengths are often adopted which requires to consider the spatial variation of the electric (and magnetic) fields within the laser pulse. Most importantly, the outer electrons of atoms or molecules are blown away already during the rising edge of the laser pulse, long before the peak intensity is reached. Therefore, one has to deal with deeply bound core electrons. They may be produced in the same laser pulse or separately by, e. g., using an EBIT. The description of the deeply bound electrons requires a fully relativistic treatment. Therefore, the proper theoretical description of atomic systems at those extreme intensities requires to solve the time-dependent Dirac equation (TDDE) in which the coupling with the field is fully taken into account beyond the dipole approximation. We have recently developed such a solver for (effective) one-electron systems in full dimensions and first results, including a newly found scaling law, will be presented.

A 1.2 Mon 11:00 V55.01

Preparation and measurement of nuclear wave packets with ultrashort laser pulses: "Lochfraß" and the inversion motion of NH_3 — •Johann Förster and Alejandro Saenz — Humboldt-Universität zu Berlin, Germany

Time-resolved imaging of the dynamics of electrons and nuclei is a prerequisite to understand chemical processes and, therefore, a great challenge for theory and experiment. Preparing and measuring nuclear wave packets describable within the promising pump-probe sheme "Lochfraß" was so far discussed theoretically [1] and experimentally [2] for diatomic molecules. The vibration of the molecule D_2 was monitored experimentally with subfemtosecond and sub-Ångstrom resolution in real time. This became possible using two identical but delayed intense ultrashort laser pulses. While so far only diatomic molecules were considered, the Lochfraß effect should be observable for larger molecules as well. The challenge for theory consists in describing this higher dimensional coupled vibrational problem and suggesting pulse parameters for the experiment. For NH_3, we expect a significant Lochfraß effect which can be understood within a simple one-dimensional double-well picture describing the inversion motion of the molecule. In addition to Lochfraß itself, also the tunneling problem in the double-well potential is of interest since a coordinate-dependent ionization rate allows the study of the wave packet traversing the inversion barrier, and thus to investigate quantum-mechanical tunneling.

[1] Goll *et al.*, *Phys. Rev. Lett.* **97**, 103003 (2006).
[2] Ergler *et al.*, *Phys. Rev. Lett.* **97**, 103004 (2006).

A 1.3 Mon 11:15 V55.01

Trajectory-based Coulomb-corrected strong field approximation — •Tian-Min Yan[1,2], Sergey Popruzhenko[3], and Dieter Bauer[1] — [1]Institut für Physik, Universität Rostock, 18051 Rostock, Germany — [2]Max-Planck-Institut für Kernphysik, Postfach 103980, 69029 Heidelberg, Germany — [3]Moscow Engineering Physics Institute, National Research Nuclear University, Kashirskoe Shosse 31, 115409 Moscow, Russia

We present a semi-classical theory for atoms in strong laser fields, the trajectory-based Coulomb-corrected strong field approximation (TCSFA). The method relies on the widely-used strong field approximation (SFA). Using the saddle point approximation, the concept of quantum orbits—inherent in the SFA—allows for an incorporation of the long-range Coulomb interaction with the emitted electron. By comparisons with *ab initio* solutions of the time-dependent Schrödinger equation we show that the Coulomb interaction significantly alters the electron dynamics. The TCSFA method is used to calculate doubly-differential momentum distributions of photo-electrons, especially for the low-energy regime where the plain SFA fails. The TCSFA is particularly convenient for a detailed analysis of the ionization dynamics at relatively low computational demand. In fact, the understanding of spectral features in terms of interfering quantum orbits yields the maximum insight possible in nonperturbative quantum dynamics. The applicability of the method for different laser parameters is discussed.

A 1.4 Mon 11:30 V55.01

The Impact of Multichannel and Multipole Effects on the Cooper Minimum in the High-Harmonics Spectrum of Argon — •Stefan Pabst[1,2], Loren Greenman[3], David A. Mazziotti[3], and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [2]Department of Physics, University of Hamburg, Germany — [3]Department of Chemistry and The James Franck Institute, The University of Chicago, Chicago, USA

We investigate the relevance of multiple-orbital and multipole effects during high-harmonic generation (HHG). The time-dependent configuration-interaction singles (TDCIS) approach is used to study the impact of the detailed description of the residual electron-ion interaction on the HHG spectrum. We find that the shape and position of the Cooper minimum in the HHG spectrum of argon changes significantly whether or not interchannel interactions are taken into account. We show that the argument of low ionization probability is not sufficient to justify ignoring multiple-orbital contributions. When additionally the tensorial character of the electron-ion interaction is neglected and a spherically symmetric electron-ion interaction is assumed, we find that the HHG yield is underestimated by up to 2 orders of magnitude in the energy range of 20-40 eV, thus modifying the shape of the Cooper minimum significantly.

A 1.5 Mon 11:45 V55.01

The lateral momentum distribution after strong-field ionization — •Ingo Dreissigacker[1], Jost Henkel[1,2], and Manfred Lein[1] — [1]Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [2]Institut für Physikalische und Theoretische Chemie and Röntgen Research Center for Complex Material Systems, Am Hubland, 97074 Würzburg, Germany

Motivated by recent measurements of the lateral electron momentum distribution from ionization with circularly polarized laser pulses [1], we model these distributions using both numerical and analytical methods. We demonstrate that in contrast to the momentum distribution in field direction, the width of the lateral distribution follows the instantaneous electric field on an attosecond timescale. This applies even in case of large fields, where substantial depletion occurs. We review the derivation of the tunneling formula, which predicts lateral distributions of approximately Gaussian shape. We demonstrate that the pre-exponential factor in the saddle-point approximation cannot be neglected if quantitative results are desired. We calculate the widths for hydrogen as well as for argon and neon atoms. We compare to results from the time-dependent Schrödinger equation and to the experimental results from [1]. We find significant improvement of our approach over the previously used tunneling formula.

[1] Arissian et al., PRL 105, 133002 (2010)

A 1.6 Mon 12:00 V55.01

Coulomb interaction in multiphoton ionization of iodine-containing molecules — •Nils Gerken, Stephan Klumpp, Martina Dell'Angela, Florian Sorgenfrei, Florian Hieke, Wilfried Wirth, and Michael Martins — Institut für Experimentalphysik, 22761 Hamburg, Germany

We present multi-ionization processes of Iodine-containing molecules and Xenon in the region of the giant resonance measured with ion mass-to-charge spectroscopy at ultrahigh intensities. In our experiment at the free-electron laser facility FLASH we reached photon intensities of up to $10^{12} - 10^{14} W/cm^2$ at pulse lengths of a few hundred femtoseconds. We observed different Coulomb interaction schemes due to different charge state distributions at two different molecular types of halides. Especially at Ion TOF - peaks belonging to higher charged Iodine atoms we can clearly observe asymmetries in our Ion time-of-flight spectra caused by Coulomb interaction. Differences of ion charge state yields for two different molecules are only observed when exposing to high photon intensities, this can be an indication for double core hole excitations. We also report on time dependent patterns of atomic xenon which is also caused by resonance excitation behavior.

A 1.7 Mon 12:15 V55.01

Electron temperature in laser-solid interaction — •Thomas Kluge, Huang Lingen, Alexander Debus, Karl Zeil, Bhuvanesh Ramakrishna, Ulrich Schramm, and Thomas E. Cowan — Helmholtz-Zentrum Dresden-Rossendorf

Recent theoretical results have led to a new understanding of how to derive the temperature of hot electrons generated in laser-solid interactions from the laser intensity.

We present new scaling laws for electron temperature with laser intensity. We then focus on the implications of our findings for applications such as laser-driven ion acceleration and laser-driven fusion using buried-layer targets.