A 22: Poster: Interaction with strong or short laser pulses

Time: Tuesday 16:30–19:00 Location: Poster.V

A 22.1 Tue 16:30 Poster.V

A Penning trap experiment for advanced studies with ions in extreme laser fields — •Manuel Vogel[1,2], Wolfgang Quint[1,3], Gerhard Paulus[4,5], and Thomas Stöhlker[1,3,5] — [1]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt — [2]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt — [3]Physikalisches Institut, Ruprecht Karls-Universität Heidelberg, 69120 Heidelberg — [4]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität, 07743 Jena — [5]Helmholtz-Institut Jena, 07743 Jena

We present a Penning trap experiment for advanced studies with confined particles in extreme laser fields. Special interest lies in non-linear processes such as multiphoton ionization. Trap-specific manipulation techniques allow control over the stored particles' localization and spatial density. It is possible to select and prepare well-defined ion ensembles and to optimize the laser-particle interaction which is of special importance when laser foci are small. Non-destructive detection of reaction products with up to single-ion sensitivity supports advanced studies by maintaining the products for further studies at extended confinement times of minutes.

A 22.2 Tue 16:30 Poster.V

Strong field ionization to multiple electronic states in water — Joe P. Farrell[1], •Simon Petretti[2], Johann Förster[2], Brian K. McFarland[2], Limor S. Spector[2], Yulian V. Vanne[1], Piero Decleva[3], Philip H. Bucksbaum[2], Alejandro Saenz[1], and Markus Gühr[2] — [1]Stanford University, USA — [2]Humboldt-Universität zu Berlin, Germany — [3]Universitá di Trieste, Italy

In this combined experimental and theoretical work the high harmonic spectrum of water molecules has been investigated [1]. The experiment uses the ratio of H_2O and D_2O high harmonic yields to isolate the characteristic nuclear motion of the molecular ionic states without the necessity of prealignment. The nuclear motion initiated via ionization of the highest occupied molecular orbital (HOMO) is small and is expected to lead to similar harmonic yields for the two isotopes [2]. However, as is shown in this work, ionization of the second least bound orbital (HOMO-1) exhibits itself via a strong bending motion which creates a significant isotope effect. We elaborate on this interpretation by simulating strong field ionization and high harmonic generation from the water isotopes using the time-dependent Schrödinger equation [3]. We expect that this isotope marking scheme for probing excited ionic states in strong field processes can be generalized to other molecules.

[1] Farrell *et al.*, Phys. Rev. Lett., **107**, 083001 (2011).
[2] Falge *et al.*, Phys. Rev. A, **81**, 023412 (2010).
[3] Petretti *et al.*, Phys. Rev. Lett., **104**, 223001 (2010).

A 22.3 Tue 16:30 Poster.V

Electron spin dynamics in a laser field — •Oleg Skoromnik[1], Iliya Feranchuk[2], Christoph Keitel[1], and Karen Hatsagortsyan[1] — [1]Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Physics Department, Belarusian State University, 4 Nezavisimosty avenue, 220030 Minsk, Belarus

In the present work the electron spin evolution in the presence of a quantized plane electromagnetic wave is considered. The initial problem for the Dirac equation was solved when the field is in the coherent state. The solution gives possibility to investigate the effect of the electron spin rotation which is originated from the quantum nature of the electromagnetic field.

A 22.4 Tue 16:30 Poster.V

Creation and Observation of Electronic Wave-Packet Motion in Atoms by Strong Field Ionization — •Lutz Fechner, Nicolas Camus, Thomas Pfeifer, Joachim Ullrich, and Robert Moshammer — Max-Planck-Institut für Kernphysik, Heidelberg

Using a pump-probe scheme for sequential double ionization of atoms in strong few-cycle laser pulses we prepare a coherent superposition of electronically excited states in the singly charged ion with the first pulse that is probed by the time-delayed second pulse. The dynamics of the electronic wave-packet, which reflects the inner structure of the particular atom, has a strong influence on both the delay dependent total ionization yield and the momentum distribution of the electrons released in the second step. In comparison to a recent experiment [1], where recoil-ion momentum spectroscopy was used, we present first kinematically complete measurements on Ne and Ar using a Reaction Microscope that allows to measure the three-dimensional momenta of all particles (ions and electrons) in coincidence.

[1] A. Fleischer *et al.*, Phys. Rev. Lett. **107** (2011), 113003

A 22.5 Tue 16:30 Poster.V

Electron emission from H_2^+ in circularly polarized strong fields including nuclear motion or full electronic coordinate space — •Myroslav Zapukhlyak[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

Inspired by recent work on strong field ionization of H_2^+ [Odenweller *et al.*, PRL **107**, 143004 (2011)] we show new quantum mechanical calculations on this molecular system in circularly polarized laser pulses. We extend previous calculations by including nuclear motion on the one hand and full three-dimensional electronic motion on the other hand. By doing so, we explore the coupled nuclear-electronic dynamics to find the most contributing nuclear distance. Regarding the anisotropy of electron emission from the fixed-in-space molecular ion, we gain additional information from the lateral width of the electronic momentum distribution, which gives depletion-insensitive information about system and laser pulse.

A 22.6 Tue 16:30 Poster.V

Electron-energy bunching in laser-driven soft recollisions — •Alexander Kästner, Ulf Saalmann, and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Dresden

We introduce soft recollisions in laser-matter interaction. They are characterized by a recollision of the electron aside the ion in contrast to the well-known head-on collisions responsible for high-harmonic generation or above-threshold ionization. We demonstrate that soft recollisions can cause a bunching of photo-electron energies through which a series of low-energy peaks emerges in the electron yield along the laser polarization axis [1]. This peak sequence is universal, it does not depend on the binding potential, and is found below an excess energy of one tenth of the ponderomotive energy. Furthermore we show that this series could be uncovered experimentally by use of few-cycle pulses with increasing pulse duration [2].

[1] A. Kästner, U. Saalmann and J.M. Rost, Phys. Rev. Lett. (in press).
[2] A. Kästner, U. Saalmann and J.M. Rost, J. Phys. B (in press).

A 22.7 Tue 16:30 Poster.V

The Physical Potential for the Tunneling Problem and Its Implementation — •Enderalp Yakaboylu, Michael Klaiber, Heiko Bauke, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik (MPIK) Saupfercheckweg 1 69117 Heidelberg, Germany

In this work, laser-driven tunnel-ionization of ionic systems in the relativistic regime is considered. After giving a phenomenological definition of tunneling, the form of the potential barrier is investigated. Therefore in a first step the gauge-dependency of the system is eliminated and conditions on the electromagnetic field that make the effective potential a physical one are found via a path dependent formalism. Then the validity of these conditions is discussed for typical laser parameters and the results of this theoretical analysis are applied to interpret numerical calculations of the problem.

A 22.8 Tue 16:30 Poster.V

Modeling atoms in laser fields using time-dependent density functional theory: Applicability of the frozen-core approximation — •Julius Rapp, Varun Kapoor, and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

We check the validity of the frozen-core approximation (FCA) in time-dependent density functional theory (TDDFT) for an atom interacting with a laser field. For this purpose we investigate an exactly solvable 1D model for Li with the help of TDDFT considering different exchange-correlation (XC) functionals. Observables such as the ionisation rate, the energy absorption rate and the dipole expectation value are obtained with and without FCA.

Comparisons among the different TDDFT results on one hand and with the exact numerical solution of the time-dependent Schrödinger equation on the other hand show that the propagation of core electrons in time does significantly affect the observables of the valence electron. Additionally, we find a strong dependency of TDDFT observables on the XC functional used even though the values for the ionisation potentials are equal.

We conclude that pseudopotentials (which apply the FCA or even bolder approximations) must yield inaccurate results in TDDFT simulations of strong-field ionization even for an otherwise exact XC functional.

A 22.9 Tue 16:30 Poster.V

Energy Quantization in double-ionization of Helium — •Kevin Henrichs, Markus Schöffler, Till Jahnke, Hendrik Sann, Maksim Kunitzki, Martin Pitzer, Christoph Goihl, and Reinhard Dörner — Institut für Kernphysik, Frankfurt (Main), Germany

ATI("above-threshold-ionization")-peaks in single-ionization have been recorded several times. In double ionization they haven*t been observed so far, but should show up in the sum-energy of the two electrons. So far the explanation is the limited energy resolution. Therefore we use a laser with a wavelength of 400 nm instead of 800 nm to increase the energy spacing of the ATI-peaks from 1.5 to 3 eV. The laser is focused on a pre-cooled super sonic gas jet. Created electrons are projected onto position and time sensitive detector using a weak electric and for guidance also a magnetic field. Helium ions are projected onto a second detector and measured in coincidence with the electrons. With this information we calculate the three-dimensional momentum vectors of the participating particles and their energies.

A 22.10 Tue 16:30 Poster.V

TDDFT on a Curvilinear Grid — •Volker Mosert and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Ultrashort and intense laser pulses provide a magnificent tool for the investigation of electronic structure of atoms and molecules. For a theoretical understanding of the underlying physics one has to deal with the time dependent many particle Schrödinger equation. A method capable of this feat—at least in principle—is the time dependent density functional theory (TDDFT). In order to model strong field effects by TDDFT one needs an efficient numerical scheme to solve the time dependent Kohn-Sham equations.

By employing a spatially homogeneous representation of the Kohn-Sham Hamiltonian the storage and propagation of the Kohn-Sham orbitals rapidly becomes infeasible for increasing ionic charges and strong laser fields. Additionally ionization dynamics may not be correctly described by pseudo potentials. Hence it is desirable to provide a high spatial resolution in the vicinity of the ions and at the same time restrict the resolution where the orbitals can be expected to be smooth. This can be achieved by a suitable coordinate transformation as was shown for the case of ground state DFT more than ten years ago. In this contribution will be shown, that this technique can also ease the computational burden in the case of time dependent calculations.

A 22.11 Tue 16:30 Poster.V

Structure of XUV frequency combs generated by trains of few-cycle pulses — •Maria Tudorovskaya and Manfred Lein — Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

The spectrum of a high-repetition train of laser pulses consists of many equally spaced lines, known as an optical frequency comb and useful in high-precision spectroscopy. By exposing atoms to a strong pulse train, it is possible to produce an XUV frequency comb by means of high-harmonic generation. In these experiments, the driving laser field does not usually have zero offset frequency, leading to order-dependent harmonic offset frequencies. We study theoretically the generation of XUV frequency combs by trains of few-cycle pulses, which generate overlapping harmonics. The structure of such combs and in particular the spacing between the "teeth" is investigated.

A 22.12 Tue 16:30 Poster.V

XUV pulse induced fluorescence of a nano plasma from argon clusters — •Lena Nösel[1], Maria Müller[1], Marcus Adolph[1], Daniela Rupp[1], Tais Gorkhover[1], Maria Krikunova[1], Tim Oelze[1], Lasse Schrödter[2], Andreas Prystawik[2], Andreas Kickermann[2], Tim Laarmann[2], and Thomas Möller[1] — [1]TU Berlin, Institut für Optik und Atomare Physik, Deutschland — [2]Hasylab/DESY, Notkestr.85, 22607 Hamburg

The high peak intensities of up to $10^{15} * W/cm^2$ of the Free Electron Laser in Hamburg (FLASH) opened up a new field for the investigation of light-matter interaction especially with pulse durations of 10 fs to 100 fs in the soft x-ray regime at 90eV. Our experiment concentrates on argon clusters where a nano plasma is formed during the interaction with the soft x-ray pulses. Fluorescence spectroscopy is used to investigate recombination processes within this nano plasma. We follow the development of fluorescence spectral lines produced by the interaction of the argon clusters with the XUV- radiation. Results of our study show that with increasing intensity of ionizing radiation the photo lines corresponding to the higher charge states increase while the lines attributed to the lower ionic charge states drop down. Furthermore, at highest achieved intensity fluorescence lines with photon energy above the XUV excitation energy of 90eV could be detected. This is indicative for non-linear processes during excitation of the clusters.(cf. [1])
[1] U.Saalmann et al., J.Phys.B:At.Mol.Opt.Phys.39(2006)R39-R77.

A 22.13 Tue 16:30 Poster.V

Probing Fano resonances with ultrashort pulses — •Jing Zhao and Manfred Lein — Institut für Theoretische Physik and Centre for Quantum Engineering and Space-Time Research (QUEST), Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

Autoionizing states in the helium atom are investigated by numerical solution of the one-dimensional two-electron Schrödinger equation for irradiation of an XUV pulse and an infrared pulse with varying time delay. By analysing the photoelectron spectrum as a function of the time delay, it is shown that the line profile of the Fano resonance is modified by the laser-induced coupling between two doubly excited autoionizing resonances. The strong coupling leads to the population of higher autoionizing states, which cannot be reached by absorbing a single XUV photon from the ground state, and the excited atom can ionize from both states. An asymmetric Autler-Townes doublet due to the strong coupling is also observed in the photoelectron spectrum.

A 22.14 Tue 16:30 Poster.V

Doppelionisation von Helium mit ultrakurzen zirkular polarisierten Laserpulsen — •Markus Schöffler[1,2], Xinhua Xie[2], Stefan Roither[2], Danil Kartashov[2], Andrius Baltuska[2], and Markus Kitzler[2] — [1]Institut für Kernphysik, J. K. Goethe-Universität Frankfurt am Main, 60438 Frankfurt — [2]Institut für Photonik, TU Wien, 1040 Wien, Österreich

Doppelionsation von Atomen in starken Laserfeldern kann sequentiell oder nicht-sequentiell ablaufen. Bei den verwendeten zirkular polarisierten Laserpulen und Intensitäten bis 2e16 W/cm2 erfolgt die Doppelionisation ausschließlich sequentiell, da Rekollision ausgeschlossen ist. Ultrakurze Laserpulse (4 fs) wurden auf einen gekühlten Helium-Überschallgasstrahl fokussiert. Die geladenen Fragmente wurden mittels der Impulsspektroskopie (COLTRIMS) gemessen. Die Impulsverteilung der He2+ Ionen zeigt zwei Ringe, welche paralleler und antiparalleler Emission der Elektronen entspricht und variiert insgesamt sehr stark mit der Intensität, Pulslänge und der CE-Phase.

A 22.15 Tue 16:30 Poster.V

Quantum orbit analysis of molecular strong-field photoelectron spectra — •Norbert Weinkauf, Tian-Min Yan, and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

Laser-induced electron diffraction is a promising method for investigating molecular structure. The photoelectron momentum distributions contain a wealth of target information and sensitively depend on the laser parameters and the orientation of the molecule with respect to the laser polarization axis. We investigate photoelectron momentum spectra by solving the time-dependent Schrödinger equation for two-dimensional model molecules. We distinguish atom-like interference effects from the orientation-dependent molecular features. In order to identify Coulomb-effects we compare with the strong-field approximation (SFA) and the recently developed trajectory-based Coulomb-corrected SFA. The latter provides ultimate insight into the underly-

ing quantum dynamics, as each spectral feature may be interpreted in terms of interfering quantum orbits.

A 22.16 Tue 16:30 Poster.V

Interference Effects in Electron-Positron Pair Creation by the Interaction of a Bichromatic Laser Field and a Nucleus — •Sven Augustin and Carsten Müller — Max-Planck-Institut für Kernphysik, Heidelberg

We investigate the creation of electron-positron pairs in the superposition of a nuclear Coulomb field and a two-colour laser field of high intensity. Herein our focus lies on quantum interference effects which may arise if the two laser frequencies are commensurate.

The interference manifests in the angular distributions of the created particles and the total pair production rates. In addition, the influence of the relative phase between the two laser modes is studied.