A 10: Poster: Interaction with strong or short laser pulses

Time: Monday 17:00–19:00 Location: C/Foyer

A 10.1 Mon 17:00 C/Foyer

Resonant Auger decay of the $4d \rightarrow 6p$ excitation in Xe driven by short intense coherent soft x-ray pulses — •Anne D Müller and Philipp V Demekhin — Institut für Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

The dynamics of the resonant Auger decay of the Xe* $4d^9_{5/2}6p_{3/2}(J=1)$ excited state induced by a short coherent and intense soft x-ray laser pulse is investigated theoretically. The present approach includes (i) the non-Hermitian coupling between the ground state and the resonance caused by the driving pulse, (ii) the interference between the coherent populations of the final ionic states by the decay of the resonance and by the direct photoionization of the ground state, and (iii) the direct ionization of the resonance itself. The individual influence of the different competing physical processes on the total ion yield and on the electron spectrum of the most intense Xe^+ $5p^4(^3P)6p\,^2P_{3/2}$ spectator Auger decay line is examined. The present numerical spectra are interpreted analytically in terms of the dynamic interference of the electron waves emitted on the rising and falling sides of the driving pulse. Our results provide a theoretical basis for experiments on the verification of the dynamic interference at currently available sources of intense high-frequency laser pulses.

A 10.2 Mon 17:00 C/Foyer

Feasibility of electron cyclotron auto-resonance acceleration by a short terahertz pulse — Yousef Salamin[1], •Jian-Xing Li[2], Benjamin Galow[3], and Christoph Keitel[2] — [1]Department of Physics, American University of Sharjah, United Arab Emirates — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69029 Heidelberg, Germany — [3]Gaisbergstraße 61, 69115 Heidelberg, Germany

We investigate conditions for an electron vacuum auto-resonance accelerator scheme that would employ circularly polarized terahertz (THz) radiation and currently available laboratory magnetic fields. The system is an electron (or electron bunch) injected in the common directions of radiation pulse propagation and a uniform magnetic field B_s. Parameter values, which could make the scheme experimentally feasible, are identified and discussed. We consider a 1000 ensemble of electrons, initially, distributed randomly within a cylinder of radius 0.232 μm and height 4.642 μm, and centered at the origin of coordinates. The ensemble is injected with kinetic energy that follows a normal distribution of mean $\bar{K}_0 = 1.022$ MeV and spread $\Delta K_0 = 0.1\%$. We used the parameter set: pulse power P = 100 TW, frequency f = 4 THz ($\lambda = 75$ μm, period $T_0 = 250$ fs = FWHM), a waist radius at focus $w_0 = 17\lambda \simeq 1.27$ mm, and $B_s = 39.6$ T. Our simulations yield a mean exit kinetic energy $\bar{K}_{exit} = 396.253 \pm 0.003$ MeV, without electron-electron Coulomb interactions, and $\bar{K}_{exit} = 396.256 \pm 0.168$ MeV, with Coulomb interactions properly taken into account. The single-particle calculations yield $\bar{K}_{exit} = 396.260$ MeV. Acceleration from rest is possible, but $B_s \simeq 300$ T, in this case.

A 10.3 Mon 17:00 C/Foyer

Collisionless shocks in laboratory plasmas — •Shikha Bhadoria, Naveen Kumar, and Christoph H. Keitel — Max-Planck-Institut fuer Kernphysik, Saupfercheckweg 1, 69117, Heidelberg, Germany

Collisionless shocks are formed when two counter-propagating streams of plasmas are collided. This situation occurs quite often in astrophysical settings e.g when the supernova remnant blast shell hits the interstellar medium etc. In a laboratory this could be easily envisaged by irradiating two energetic laser pulses on thin-foil targets placed opposite to each other. These collisionless shocks are responsible for extreme acceleration of charged particles (e.g. cosmic rays) by Fermi acceleration mechanism, however little is known about their formation process. We present results of collisionless shock formation in a laboratory and discuss their implications for the astrophysical scenario.

A 10.4 Mon 17:00 C/Foyer

Double-slit electron interference in strong-field ionization of argon dimers — Kevin Henrichs, Nikolai Schlott, •Alexander Hartung, Maksim Kunitski, and Reinhard Dörner — Institut für Kernphysik, Goethe Universität Frankfurt, Max-von-Laue-Str. 1, D-60438 Frankfurt am Main, Germany

Wave-like behavior of particles, e.g. interference, is *"the mystery"*, as stated by Feynman, *"which is impossible, absolutely impossible, to explain in any classical way, and which has in it the heart of quantum mechanics"*. In the 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]. Several such experiments have been reported so far [2-6].

Here we report the observation of photo-electron double-slit interference in single ionization of argon dimer by a strong ultra-short laser field (40 fs, 790 nm, $1.8 \cdot 10^{14}$ W/cm^2). An electron and a single Ar ion resulting from break-up of $Ar_2{}^+$ along the repulsive $II(1/2)_g$ potential were measured in coincidence by means of COLd Target Recoil Ion Momentum Spectroscopy (COLTRIMS) [7]. The molecular axis of Ar_2 upon ionization was deduced from the momentum direction of the detected Ar ion. [1] H. D. Cohen, U. Fano, Phys Rev 150, 30-33 (1966) [2] D. Rolles et al., Nature 437, 711-715 (2005) [3] X.-J. Liu et al., J. Phys. B At. Mol. Opt. Phys. 39, 4801 (2006) [4] D. Akoury et al., Science 318, 949-952 (2007) [5] Z. Ansari et al., New J. Phys. 10, 093027 (2008) [6] S. E. Canton et al., Proc. Natl. Acad. Sci. 108, 7302-7306 (2011) [7] J. Ullrich et al., Rep. Prog. Phys. 66, 1463 (2003).

A 10.5 Mon 17:00 C/Foyer

Spin polarization of electrons in a strong laser field — Alexander Hartung, •Alina Laucke, Maksim Kunitski, and Reinhard Dörner — Institut für Kernphysik, Goethe-Universität Frankfurt am Main

Atoms exposed to a strong laser field (intensities in the range of $10^{14}\,W/cm^2$ and higher at $800\,nm$) are efficiently ionized. I. Barth and O. Smirnova predicted that electrons which are created by strong-field-tunnelionization from rare gas atoms are spin polarized [1]. They propose two effects to be responsible for the spin selectivity: first, they argue that the probability for tunnelionization by circular light depends on the sign of the magnetic quantum number m of the electron [2]. Second, there are different strong-field-tunnelionization probabilities for different electron spins because the spin-orbit-interaction makes electrons with spin parallel to m more weakly bound than those with spin antiparallel to m.

We have performed a first experiment on Xenon, ionized by a circularly polarized $800\,nm$ laser pulse at peak intensities of 4.4 and $6.6 \cdot 10^{14}\,W/cm^2$ [3]. We used a Spin Mott detector in order to measure the spin polarization of the photo-electrons. The preliminary results strongly indicate the existence of this theoretically predicted spin-polarization. The experimentally measured strength of the effect as well as the electron energy and intensity dependences are in good agreement with the theory. [1] I. Barth, O. Smirnova; Phys. Rev. A 88, 013401 (2013) [2] I. Barth, O. Smirnova; Phys. Rev. A 84, 063415 (2011) [3] A. Hartung; Master Thesis, University Frankfurt (2014)

A 10.6 Mon 17:00 C/Foyer

Spin effects in elliptically polarized laser fields in tunnel-ionization — •Enderalp Yakaboylu, Michael Klaiber, and Karen Z. Hatsagortsyan — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Spin effects in the tunneling regime of strong field ionization of hydrogenlike highly charged ions in a laser field of elliptical polarization are investigated. The spin-resolved differential ionization rates are calculated employing the dressed relativistic strong-field approximation (SFA), which takes into account the laser driven spin dynamics in the bound state. Analytical expressions for spin asymmetries as well as for the differential probabilities of spin transitions are obtained for the photoelectron momentum corresponding to the maximal tunneling probability. Intuitive explanations for the spin dynamics are provided introducing a simpleman model. The physical relevance of the applied dressed SFA, which is based on a non-standard partition of the total Hamiltonian, is discussed versus the standard SFA.

A 10.7 Mon 17:00 C/Foyer

Ionization of atoms and molecules in a strong two-color field — •Yonghao Mi, Nicolas Camus, Martin Laux, Lutz Fechner, Robert Moshammer, and Thomas Pfeifer — Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany

We experimentally investigated the asymmetry of photo-ion and photoelectron momentum spectra of argon and nitrogen. The spectra are obtained by using reaction microscope(COLTRIMS), in which an argon-nitrogen gas mixture is ionized in a strong two-color (400 nm + 800 nm) laser field. By changing the time delay t between the 400 nm laser pulse and the 800 nm pulse, the fan-like stripes in low-energy electron momentum shift from negative momentum to positive for both argon and nitrogen. A phase difference of asymmetric electron emission between Ar and N2 is observed.

A 10.8 Mon 17:00 C/Foyer

Vlasov simulation for laser-plasma interaction — •Suo Tang, Naveen Kumar, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69126, Heidelberg, Germany

Vlasov simulation of laser-plasma interaction has an inherent advantage of low-noise over the well-known method of particle-in-cell (PIC) simulation. In addition to studying the nonlinear physics of laser-plasma interaction, cross section of certain quantum processes can be included in the Vlasov equation as the source term, making it a versatile tool to study the intense laser-matter interaction. Results of the intense laser-matter interaction physics including some quantum effects from a recently developed 1D Vlasov code are presented.

A 10.9 Mon 17:00 C/Foyer

Strong bichromatic laser field ionization of atoms and "the phase of the phase" in the photoelectron yield — •Mohammad Adel Almajid and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock, Germany

There have been various attempts to include Coulomb effects into the plain strong field approximation (SFA), one of them being the Coulomb-Volkov approximation (CVA). In our work, we consider two-color, colinearly polarized laser pulses. The relative phase between the two field components affects the photoelectron dynamics. A pronounced disagreement between exact TDSE and CVA-SFA photoelectron spectra is found for low energies. The rescattered electrons instead are well described already by the SFA (extended for the rescattering matrix element). We analyze the photoelectron spectra by Fourier-transforming the momentum-dependent yield as a function of the relative phase between the two pulses, thus obtaining "the phase of the phase". Plotted vs the momenta parallel and perpendicular to the laser polarization direction, this entity tells how the yield of photoelectrons with a certain final momentum is synchronized with respect to changes of the relative phase. The overall structure of these phase-of-the-phase spectra can be understood in terms of quantum trajectories while details are target-sensitive.

A 10.10 Mon 17:00 C/Foyer

Ion emission from argon microdroplets exposed by ultrashort intense laser pulses — •Lev Kazak, Robert Irsig, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Insitute of Physics, University of Rostock, Universitätsplatz 3, 18051 Rostock, Germany

The liquid jets are attractive targets for laser-generated plasma investigation. From the one side it gives a great opportunity to study the properties of warm dense matter, from the other side they are interesting as possible candidate of X-ray and extreme ultraviolet (XUV) light sources. In the present study we concentrate on the ionization and heating of the microdroplets. The kinetic energies of the ions emitted from the droplets are simultaneously measured by field-free time-of-flight spectrometers located in laser propagation and counter-propagation directions. First results show a strong asymmetry. Ions with higher recoil energy are emitted predominately in the direction opposite to the laser propagation. The impact of the laser pulse parameters will be discussed.

A 10.11 Mon 17:00 C/Foyer

Exploring quantum dynamics without time propagation — •Mehrdad Baghery, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

According to Schrödinger equation, the dynamics of a quantum system is obtained by successively applying the time evolution operator to the wavefunction. This procedure, thought seemingly simple, is not parallel in general, and this may become an obstacle as the size of the system increases.

In this study, time and space are treated on an equal footing, i.e. basis functions are used in both time and space to describe the evolution of the system. This way, one can find a system of sparse linear equations whose solution gives the evolution of the wavefunction as function of time. Considering the fact that solving a system of sparse linear equations may be parallel, the hope is to find a method to calculate the evolution of a quantum system using a parallel algorithm.

A 10.12 Mon 17:00 C/Foyer

Charge Transfer in XFEL Irradiated Biomolecules — •Abraham Camacho Garibay, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden

The possibility of single-molecule-diffractive imaging using intense XFEL pulses was suggested [1] long before these machines were operational. In this pioneering work the possibility of "diffraction before destruction" was demonstrated to be feasible, yet requiring rather high intensities and very short pulses. The important effect of charge transfer [2], neglected in this first approach, has been proven to drive a coulomb explosion were different elements escape the molecular environment in a non-homogeneous way. Here we calculate the electron and ion dynamics for molecules in an XFEL pulses, where we observe a systematic electron migration from hydrogen atoms (intrinsically abundant in biological environments) to heavier, more absorbing and scattering elements. This gives rise to the stabilization of the molecular backbone which allows the use of longer pulses and/or weaker intensities in imaging experiments.

[1] Neutze et. al., Nature 406, 2000
[2] DiCintio et. al., PRL 111, 2013

A 10.13 Mon 17:00 C/Foyer

Molecular wave-packet dynamics on laser controlled transition states — •Andreas Fischer[1], Martin Gärttner[1], Philipp Cörlin[1], Alexander Sperl[1], Michael Schönwald[1], Tomoya Mizuno[1], Giuseppe Sansone[2], Arne Senftleben[3], Joachim Ullrich[4], Bernold Feuerstein[1], Thomas Pfeifer[1], and Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Dipartimento di Fisica, Politecnico Milano, Piazza Leonardo da Vinci 32, 20133 Milano , Italy — [3]Institut für Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel — [4]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Using a kinematically complete XUV-pump IR-probe experiment, we have studied the dissociation dynamics of molecular hydrogen induced by ultra-short extreme-ultraviolet (XUV) and near-infrared (IR) laser pulses by varying the time delay between these pulses. The measured fragment velocities are time-delay dependent, showing that the reaction kinematics can be controlled by varying the retardation of the control pulse. A semi-classical model, supported by a quantum dynamics simulation, provides an intuitive understanding of the underlying mechanism in terms of particle motion on laser-induced potential energy surfaces.

A 10.14 Mon 17:00 C/Foyer

Strong Field Ionization of atoms with elliptically polarized light — •Nicolas Camus[1], Lutz Fechner[1], Andreas Krupp[1], Lukas Heizmann[1], Joachim Ullrich[2], Thomas Pfeifer[1], and Robert Moshammer[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

We present kinematically complete strong field ionization of atoms by elliptically polarized light.

We experimentally produce arbitrary elliptically polarized light using a Mach-Zehnder interferometer. This optical setup allows shaping the polarization state of femtosecond pulses for a broad range of wavelengths. Using a Reaction Microscope, we are able to measure the three-dimensional momentum vector of all ionization fragments in coincidence.

Analyzing their momentum distribution allows to test current theories about tunneling of electron in elliptical/circular strong laser fields. More important, the dependence of these theories on the Keldysh parameter (describing which ionization picture is more relevant: tunneling or multi-photon) is investigated through the variation of target, intensity and wavelength of the laser used in the experiment.

A 10.15 Mon 17:00 C/Foyer

Seeded resonant Ionization of Xenon Doped Helium Droplets — •Michael Kelbg, Lev Kazak, Robert Irsig, Josef Tiggesbäumker, and Karl-Heinz Meiwes-Broer — Instut für Physik, Universität Rostock, Germany

The interaction of doped helium droplets with intense, short laser pulses is studied. Colored double pulse fitness landscape is used to control the ionization of minimally Xenon-doped helium droplets resulting in mie-resonant enhanced absorbtion. Dependencies on delay and energy distribution as well as amount of dopant atoms have been further investigated, revealing an avalanchelike two step ionization process.

A 10.16 Mon 17:00 C/Foyer

Tracing the nano-plasma evolution in clusters induced by intense FEL and NIR pulses — •M. Müller[1], D. Rupp[1], L. Flückiger[1], M. Sauppe[1], J.-P. Müller[1], A. Ulmer[1], B. Langbehn[1], S. Toleikis[2], Y. Ovcharenko[1], and T. Möller[1] — [1]TU Berlin, Hardenbergstr. 36, 10623 Berlin — [2]DESY, Notkestr. 85, 22607 Hamburg

The interaction of short and intense light pulses with nano-particles results in the formation of spatial confined, solid density nano-plasmas. To understand the processes creating and driving the nano-plasma can be important for ultrafast strong field nano-plasmonics [1] as well as all experiments where the plasma formation as a byproduct cannot be avoided. We investigate the evolution of the nano-plasma time dependently in a two color pump probe scheme with scattering images and ion-spectroscopy. A short wavelength free electron laser(FEL) pulse from FLASH at DESY images the initial state and starts the nano-plasma formation while the plasma is probed with near infrared (NIR) pulses. In addition, in a second type of experiment with reversed order of the pulses the process of plasma formation and disintegration induced by a NIR pulse can be traced by recording scattering patterns with FEL pulses. The poster will give an overview on initial experiment and present first results. [1]: Kim et al., Nature 453, 757-760 (5 June 2008)

A 10.17 Mon 17:00 C/Foyer

In-flight-holography – a novel approach to image single nanoparticles with highly intense X-ray pulses — •A. Ulmer[1], J. Andreasson[2], A. Barty[2], J. Bielecki[2], M. Bucher[3], B. Daurer[2], D. DePonte[3], T. Ekeberg[2], G. Faigel[5], K.R. Ferguson[3], M.F. Hantke[2], D. Hasse[2], F. Maia[2], A.J. Morgan[4], K. Mühlig[2], M. Müller[1], C. Nettelblad[2], K. Okamoto[2], A. Pietrini[2], M. Sauppe[1], M.M. Seibert[2], J.A. Sellberg[2], M.S. Svenda[2], E.N. Timneanu[2], G. van der Schot[2], A. Zani[2], H.N. Chapman[4], J. Hajdu[2], C. Bostedt[3], T. Möller[1], and T. Gorkhover[3] — [1]TU Berlin — [2]LCLS@SLAC — [3]Uppsala University — [4]CFEL@Desy Hamburg — [5]Hungarian Academy of Sciences

Free-Electron Lasers provide coherent highly intense and short pulses which make it possible for the first time to analyze the morphology of non-periodic or non-crystallizable nanoparticles by elastic light scattering. As the phase information is lost due to the imaging process it has to be retrieved to extract full structural information. In former approaches sophisticated techniques were necessary in order to regain the phase. For solid targets holographic methods were applied successfully which retrieve the phase information in a much faster and less expensive way. We recently developed single-shot in-flight-holography using pulses from the Linac Coherent Light Source (LCLS) to image undistorted viruses in water droplets using the scattered light from xenon nanoclusters as a reference wave. First results and resolution limits through experimental constraints will be discussed.