A 9: Interaction with strong or short laser pulses I

Time: Monday 16:30–18:30 Location: B 305

Invited Talk A 9.1 Mon 16:30 B 305

Attosecond physics at a nanoscale metal tip — •Peter Hommelhoff[2,1], Michael Krüger[1], Michael Förster[1], Sebastian Thomas[1], Lothar Maisenbacher[1], Peter Dombi[1], Johannes Hoffrogge[1], Jakob Hammer[1], Dominik Ehberger[1], John Breuer[1], Georg Wachter[3], Christoph Lemell[3], and Joachim Burgdörfer[3] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [2]Physik-Department, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen — [3]Theoretische Physik, TU Wien, Wiedner Hauptstraße 8-10, A-1040 Wien

We focus few-cycle laser pulses onto sharp metal tips. Electrons are emitted from the apex of the tip, and their energy is analysed. We observe a strong carrier-envelope phase (CEP) dependence and can switch on and off the high-energy part of the electron current by the CEP. We can describe the spectra with the three-step model borrowed from high-harmonic generation in atomic gases. Because of the broken symmetry in tip-based experiments, the spectra can be explained with few trajectories only, alleviating their interpretation. We will compare the spectra to more appropriate TDDFT simulation results and will report on ongoing experiments focusing on understanding the interaction of few-cycle laser pulses and nanoscale matter on sub-fs time scales.

A 9.2 Mon 17:00 B 305

Imaging the nanoplasma of single large xenon clusters with the Free-Electron Laser FLASH — •D Rupp[1], M Adolph[1], L Flückiger[1], T Gorkhover[1], M Krikunova[1], M Sauppe[1], D Wolter[1], S Toleikis[2], R Treusch[2], S Schorb[3], C Bostedt[3], and T Möller[1] — [1]TU Berlin — [2]Hasylab@DESY — [3]LCLS@SLAC

Intense short pulses from Free-Electron Lasers in the short wavelength regieme as FLASH provide access to new fields of experiments such as imaging of single nanosized structures. We use rare gas clusters as ideal targets to study the interaction between matter and strong light pulses in a combined approach of measuring both ion spectra and scattered light. From the scattering patterns of single clusters, the particle size can be extracted, but also light induced changes in the clusters on a fs timescale are encoded in the scattered light [1]. Intensity profiles of the scattering patterns analyzed with Mie's theory yield optical properties of the clusters. Strong modulations found in intense patterns of large clusters point to the formation of a core-shell system of the nanoplasma with a highly absorbing core and a weakly absorbing, tens of nanometers thick shell. In contrast, the ion spectra of the same clusters indicate the explosion of highly charged ions from only a very thin outer shell driven by coulombic repulsion and effective recombination of the remaining, quasi-neutral nanoplasma. Those results emphasize the capability of simultaneous imaging and ion spectroscopy of single clusters, to address different timescales of a complex process and thus gain a more complete picture.

[1] C. Bostedt et al, PRL 108, 093401 (2012)

A 9.3 Mon 17:15 B 305

Time-dependent density functional calculations of enhanced fast electron emission from laser-irradiated sodium clusters — •Thomas Keil and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock

The investigation of clusters promises insight into the transition from atomic systems to the bulk material. Moreover, this transient regime gives rise to a variety of phenomena driven by collective effects in small systems subject to intense laser pulses [1,2], such as enhanced absorption and scattering of radiation and modified cut-offs in photoelectron spectra.

We study the interaction between short intense laser pulses and sodium clusters. A comparison with the hydrogen atom shows that for clusters the emission of fast electrons is significantly increased. This effect is studied using time-dependent density functional theory and a jellium cluster model.

We calculate electron energy spectra to show correlations between electron-electron interaction and the effect of increased fast electron emission. We identify collective effects in the multipole-expanded interaction potentials and characterize the underlying acceleration mechanism.

[1] Th. Fennel et al., Rev. Mod. Phys. 82, 1793 (2010).
[2] Th. Fennel et al., Phys. Rev. Lett. 98, 143401 (2007).

A 9.4 Mon 17:30 B 305

Adiabatic versus nonadiabatic effects in tunneling ionization of atoms — •Antonia Karamatskou[1,2], Stefan Pabst[1,2], and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Hamburg, Germany — [2]Department of Physics, University of Hamburg, Hamburg, Germany

We discuss the tunneling regime of atoms in a strong laser field within the framework of the adiabatic representation. This representation is commonly used in the field of molecular dynamics, where the motion of the nuclei is assumed to be so slow compared to the electronic motion that it justifies the usage of the Born-Oppenheimer approximation. This yields discrete potential energy curves of the system that are connected by nonadiabatic transitions. Here, we extend this method to the treatment of the strong-field ionization of atoms. By adding a complex absorbing potential the Hamiltonian becomes non-Hermitian. In this way, we obtain discrete eigenstates and the associated complex eigenvalues contain the physical tunneling rates. Via the full diagonalization of the instantaneous Hamiltonian we are able to observe the transition from the adiabatic regime to the region where nonadiabatic transitions become significant for the ionization. In our study we also clarify the impact of few-cycle pulses on the tunneling behavior. Thereby we refine the language employed for nonadiabaticity in strong field physics. Furthermore, we analyze the usage of the Keldysh parameter as an adiabaticity parameter for strong field ionization.

A 9.5 Mon 17:45 B 305

Geometric effects in dopant-induced helium nanoplasmas — Barbara Grüner, Manuel Rometsch, Frank Stienkemeier, and •Marcel Mudrich — Physikalisches Institut, Universität Freiburg

He nanodroplets are widely used as a cold and weakly perturbing matrix for studying embedded molecules and clusters by laser spectroscopy. However, when the impurity atoms are ionized using strong NIR laser pulses the He droplets can turn into highly absorbing nanoplasmas. As a result, we measure high yields of He^+ and He^{2+} ions as well as increased charge states of the impurities compared to the neat impurity clusters. Surprisingly, we find the efficiency of igniting the He nanoplasma to strongly depend on the location of the impurities with respect to the droplet surface, as demonstrated using alkali and earth-alkali metals instead of rare gases as dopants.

A 9.6 Mon 18:00 B 305

Characterization of an axis-density modulated plasma waveguide based on laser-cluster interaction — •yin tao[1], siew jean goh[1], peter van der slot[1], bert bastiaens[1], edwin van der weide[1], rob hagmeijer[1], jennifer herek[1], sandra biedron[2], steven milton[2], miltcho danailov[3], and klaus boller[1] — [1]Laser Physics and Nonlinear Optics, Optical Sciences, Engineering Fluid Dynamics, Mesa+ Institute for Nanotechnology, University of Twente, Enschede, The Netherlands — [2]Colorado State University, Colorado, USA — [3]FERMI@Elettra, Sincrotrone Trieste S.C.p.A., Basovizza, Trieste, Italy

We investigate the possibility to realize a fully coherent light source emitting XUV down to 4 nm by using high harmonic generation (HHG) in an ionized medium. However, due to the strong ionization, current phase-matching techniques for HHG are not suitable. Instead, we will investigate quasi-phase matching (QPM) and wave guiding over an extended interaction length to increase the output pulse energy. For this, we will ionize a density modulated cluster jet to prepare a plasma waveguide with an appropriate density modulation along its axis for QPM. Here, we first report on the characterization of the argon cluster jet with a modulated grid. We employ Rayleigh scattering imaging and interferometry to infer the cluster size and the density distribution in the jet. Later, the modulated plasma waveguide will be generated. We present the temporal and spatial evolution of total electron density as measured by transverse interferometry technique. Additionally, the shortest possible modulation period will be discussed.

A 9.7 Mon 18:15 B 305

Autoionization of Helium Nanodroplets Induced by Intense

VUV Light Pulses — •Aaron LaForge[1], Michele Alagia[6], Lorenzo Avaldi[2], Carlo Callegari[3], Marcello Coreno[2], Michele Devetta[4], Marcel Drabbels[5], Raphael Katzy[1], Antti Kivimaki[6], Viktor Lyamayev[1], Tommaso Mazza[7], Thomas Möller[8], Marcel Mudrich[1], Yevheniy Ovcharenko[8], Paolo Piseri[4], Kevin Prince[3], Robert Richter[3], Michele Di Fraia[10], Stefano Stranges[9], and Frank Stienkemeier[1] — [1]Universität Freiburg, Germany — [2]CNR-IMIP Rome, Italy — [3]Sincrotrone Trieste, Italy — [4]University of Milan, Italy — [5]EPFL Lausanne, Switzerland — [6]CNR-IOM Trieste, Italy — [7]European XFEL GmbH, Germany — [8]Technische Universität Berlin, Germany — [9]University of Rome "Sapienza", Italy — [10]University of Trieste

Ionization of helium nanodroplets was performed by the VUV-seeded FEL FERMI@Elettra. Using the unique tunability of the seed laser along with the high intensity of the FEL, it is possible to resonantly excite the nanodroplets such that almost the entire cluster is excited. In this state, neighboring excited atoms can decay via energy transfer similar to a doubly excited state decaying by autoionization. This effect leads to an enhancement in the abundance of ions. To observe the effects, one compares the power dependencies on the ion yield for various excited states to those of non-resonant ionization and direct ionization.