A 9: Interaction with strong or short laser pulses

Time: Tuesday 16:30–18:30 Location: P

A 9.1 Tue 16:30 P

Modeling ultrashort laser pulses in nonlinear media using FDTD — •Jonas Apportin, Christian Peltz, Björn Kruse, Benjamin Liewehr, and Thomas Fennel — Institute for Physics, Rostock, Germany

The Finite-Differences-Time-Domain (FDTD) method provides a real-time solution to Maxwell's equations on a spatial grid that can be easily extended by rate equations for e.g. ionization and is therefore optimally suited for the modeling of nonlinear laser-material interaction close to the damage threshold. However, the tight focusing conditions associated with high laser intensities result in non-Gaussian beam profiles that no longer obey the typically applied paraxial approximation, thereby considerably complicating their description within the FDTD framework. We apply an efficient description of such tightly focused beams, based on the decomposition of the laser profile into plane waves and their separate propagation including the compensation of numerical dispersion. The nonlinear material response is modeled using nonlinear Lorentz oscillators for Kerr-type nonlinearities [1] and Brunel as well as injection currents associated with the excitation of electrons into the conduction band for higher order nonlinearities [2]. First simulation results for strong and ultrashort laser pulses tightly focused into thin fused silica films ($d \approx 10\mu m$) show the formation of a pronounced ionization grating due to standing waves at the rear material surfaces.

[1] C. Varin et al., Comput. Phys. Commun. **222** 70-83 (2018)

[2] P. Jürgens et al., Nature Physics **160**, 1035-1039 (2020)

A 9.2 Tue 16:30 P

Ignition of a helium nanoplasma by pump-probe multiple ionization of a dopant core — •Cristian Medina[1], Dominik Schomas[1], Markus Debatin[1], Ltaif Ltaif[2], Robert Moshammer[3], Thomas Pfeifer[3], Hoque Ziaul[4], Andreas Hult[4], Maria Krikunova[4], Frank Stienkemeier[1], and Marcel Mudrich[2] — [1]University of Freiburg , Freiburg , Germany — [2]Aarhus University, Aarhus , Denmark — [3]Max-Planck-Institut für Kernphysik, Heidelberg. Germany — [4]- Extreme Light Institute, Prague, Czech Rep.

Helium nanoplasmas are usually created by intense near-infrared laser pulses. After tunnel ionization of the cluster or some dopant atoms, the cluster fully avalanche-ionizes as the electrons are driven back and forth through the cluster by the laser field. We demonstrate a different scheme for igniting the nanoplasma on doped helium nanodroplets. An ultrashort X-ray pulse (FLASH-1 at DESY, Hamburg) or the 19th higher harmonics from an 800 nm pulse (ELI, Prague) first inner-shell ionizes the dopant cluster, followed by Auger decay and charge-transfer ionization of the helium shell. A second near-infrared pulse drives the nanoplasma at variable delay with respect to the pump pulse. At certain delay times, a resonance appears, indicated by an increase of the ignition probability, evidenced by the rise of He+ and He2+ ion yields, the hit rate as well as the electron kinetic energy.

A 9.3 Tue 16:30 P

HILITE - stored ions for non-linear laser-ion experiments — •Markus Kiffer[1], Stefan Ringleb[1], Nils Stallkamp[1,2], Belá Arndt[3], Sugam Kumar[4], Gerhard Paulus[1,5], Wolfgang Quint[2,6], Thomas Stöhlker[1,2,5], and Manuel Vogel[2] — [1]Friedrich-Schiller-Universität, Jena — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [3]Goethe Universität Frankfurt, Frankfurt — [4]Inter-University Accelerator Centre, New Delhii — [5]Helmholtz-Institut Jena, Jena — [6]Ruprecht Karls-Universität Heidelberg, Heidelberg

The development of free-electron lasers with photon energies in the XUV to X-ray regime opens up new possibilities to investigate nonlinear laser-matter interaction. Ionic systems with only one active electron are of particular interest - especially hydrogen-like systems.

To investigate such systems we have built and commissioned the HILITE (**H**igh-**I**ntensity **L**aser **I**on-**T**rap **E**xperiment) Penning trap. The ions are produced by an Electron-Beam Ion Trap (EBIT), selected by a Wien filter, and captured dynamically in the trap centre.

Last year we conducted our first Beam time at the FLASH2 FEL laser facility at DESY in Hamburg, where we wanted to investigate two photon ionisation of O^{5+}. We have had to deal with unexpectedly bad vacuum conditions which limited the storage time and significantly increased the background signal.

We will present the setup, the commissioning results and results from our first beamtime. We will also present envisaged upgrades of the setup.

A 9.4 Tue 16:30 P

Strong-field ionization mechanisms of selectively prepared doubly excited states in helium — •Gergana D. Borisova[1], Hannes Lindenblatt[1], Severin Meister[1], Florian Trost[1], Patrizia Schoch[1], Veit Stooss[1], Markus Braune[2], Rolf Treusch[2], Harald Redlin[2], Nora Schirmel[2], Paul Birk[1], Maximilian Hartmann[1], Christian Ott[1], Robert Moshammer[1], and Thomas Pfeifer[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Deutschland — [2]Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Deutschland

Atomic and molecular systems have one, or a few, energetically lowest ground states but a multitude of excited states, all exhibiting different electron correlation. To gain new insights into the role of the initial state, with its specific electron correlation, for the ionization process, we conducted a two-color extreme ultraviolet (XUV)-infrared (IR) experiment using a reaction microscope (ReMi) to study IR strong-field ionization out of selectively prepared doubly excited states in helium in the XUV energy region between 59 eV and 80 eV, with XUV light provided by the free-electron laser in Hamburg FLASH. Both single- and double-ionization have been observed and the impact of different strong-field ionization mechanisms will be discussed, also in comparison with model calculations.

A 9.5 Tue 16:30 P

Contributions of edge-currents on the high-order harmonic generation in topological insulators — •Christoph Jürss and Dieter Bauer — University of Rostock, Institute of Physics, Rostock, Germany

Edge-states in topological insulators are localized on the edge of the solid system. They are robust against various perturbations. Edge currents allow a scatter-free electronic transport along the edge of the solid. In our work, the influence of edge-currents in the topological Haldanite material is simulated. The harmonic spectra for finite and the bulk system are compared and the contributions from the edge are identified. The frequency of the emitted light from the edge-current strongly depends on the size of the material, which opens new possibilities for multiple applications.

A 9.6 Tue 16:30 P

Imaging ultrafast laser-driven dynamics in thin foils via inline holography — •Richard Altenkirch, Christian Peltz, Franziska Fennel, Stefan Lochbrunner, and Thomas Fennel — Institute for Physics, Rostock, Germany

Well controlled laser material processing with a spatial resolution on the scale of the laser wavelength is key to the realization of a large variety of applications. Respective developments will strongly benefit from a full spatial and temporal characterization of the laser-induced plasma evolution. To this end, we implemented an experiment based on coherent diffractive imaging (CDI), a technique well known from free particle characterization using XUVs and Xrays [1]. The probe pulse images the spatial plasma profile evolution induced by the pump pulse in a thin gold foil. The resulting scattering images are used for a reconstruction via phase retrieval [2]. In contrast to typical Xray CDI experiments, we record a superposition of scattered radiation and the radiation transmitted through the intact foil, leading to holographic signatures. Here, we present a systematic numerical analysis of the role of these holographic features for the object reconstruction as well as the optimal experimental conditions. We further present a first successful application of the reconstruction method to experimental data, i.e. laser-drilled holes.

[1] H. Chapman et al., Nature Physics **2** 839-843 (2006)

[2] J. Fienup, Appl. Opt. **21**, 2758-2769 (1982)