A 33: Interaction with strong and short laser pulses

Time: Thursday 16:15–18:15 Location: S Fobau Physik

A 33.1 Thu 16:15 S Fobau Physik

High-Harmonic Generation in a Su-Schrieffer-Heeger Chain — •Christoph Jürss and Dieter Bauer — Institute of Physics, University of Rostock, Germany

High-harmonic spectra for two topological phases of a one-dimensional, linear chain were investigated previously using time dependent density functional theory [1]. A significant difference in the dipole strength between the two topological phases were observed and explained by destructive interferences of emitted light from the electrons in the valence band. We obtain similar results as we couple the tight-binding based Su-Schrieffer-Heeger (SSH) model to an external field. Edge states and spectra in this model are quite robust against random fluctuations of the system. Additionally the bulk-boundary correspondence is investigated by focusing the laser to certain areas of the chain.

[1] D. Bauer and K. K. Hansen, Phys. Rev. Let. **120**, 177401 (2018)

A 33.2 Thu 16:15 S Fobau Physik

Above-threshold ionization beyond dipole approximation in the SFA — •Birger Böning[1,2], Willi Paufler[1,2], and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, Germany — [2]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Germany

We theoretically investigate non-dipole effects in the above-threshold ionization (ATI) of atoms using the strong-field approximation (SFA). To this extend, we construct Volkov-like continuum wavefunctions of the photoelectron in laser fields with arbitrary spatial dependence. Based on previous work, we show how to construct these solutions to the Schrödinger equation for an electron in a laser field that can be written as a continuous superposition of plane waves. As an application, we perform detailed computations of ATI spectra within the SFA and discuss contributions due to non-dipole interactions. In particular, the peak shift of the spectra in laser propagation direction for mid-IR fields is shown.

A 33.3 Thu 16:15 S Fobau Physik

Three-dimensional imaging of light induced dynamics in xenon doped superfluid helium nanodroplets — •B. Langbehn[1], K. Sander[2], Y. Ovcharenko[1,3], C. Peltz[2], A. Clark[4], M. Coreno[5], R. Cucini[6], M. Drabbels[4], P. Finetti[6], M. Di Fraia[6,5], L. Giannessi[6], C. Grazioli[5], D. Iablonskyi[7], A. C. LaForge[8], T. Nishiyama[9], V. Oliver Álvarez de Lara[4], P. Piseri[10], O. Plekan[6], K. Ueda[7], J. Zimmermann[1,11], K. C. Prince[6,12], F. Stienkemeier[8], C. Callegari[6,5], T. Fennel[2,11], D. Rupp[1,11], and T. Möller[1] — [1]TU Berlin — [2]Univ. Rostock — [3]European XFEL — [4]EPFL Lausanne — [5]ISM-CNR Trieste — [6]Elettra-Sincrotrone Trieste — [7]Tohoku Univ. Sendai — [8]Univ. Freiburg — [9]Kyoto Univ. — [10]Univ. di Milano — [11]MBI Berlin — [12]Swinburne Univ. of Tech.

Intense short-wavelength femtosecond light pulses delivered by free-electron laser (FEL) facilities allow to investigate the structure and dynamics of nanometer-sized objects via coherent diffractive imaging (CDI) methods. We studied single helium nanodroplets doped with xenon using extreme ultraviolet (XUV) femtosecond light pulses delivered by the FERMI FEL. When irradiated by a high power infrared (IR) laser pulse, a nanoplasma will be ignited inside the droplets that can be observed in the diffraction pattern from a delayed XUV pulse. The nanoplasma propagation and destruction of the droplets was traced via single-particle imaging from femtoseconds up to hundreds of picoseconds after IR excitation.

A 33.4 Thu 16:15 S Fobau Physik

HILITE - A tool to investigate the interaction of laser light with matter — •Nils Stallkamp[1,2], Stefan Ringleb[2], Markus Kiffer[2], Bela Arndt[3], Sugam Kumar[4], Manuel Vogel[1], Wolfgang Quint[1,5], Gerhard Paulus[2], and Thomas Stöhlker[1,2] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [2]Friedrich Schiller Universität Jena — [3]Goethe Universität Frankfurt am Main — [4]Inter University Accelerator Centre Delhi — [5]Ruprecht Karls Universität Heidelberg

The investigation of laser-ion interactions in a detailed way, require well-defined ion targets and detection techniques for high-sensitivity measurements of reaction educts and products. To this end, we have designed and built the HILITE (High-Intensity Laser-Ion Trap Experiment) Penning trap setup, which features various ion-target preparation techniques including selection, cooling, compression and positioning as well as destructive and non-destructive measurement techniques to determine the number of stored ions for all charge states individually and simultaneously. Recently, first commissioning experiments of ion deceleration and dynamic ion capture with highly charged ion bunches from an electron beam ion source (EBIT) have been performed. We have characterised our single-pass non-destructive ion counter in detail and were able to determine the ion velocity as well as the number of ions from the signals acquired. Furthermore, storage times inside the trap in the order of minutes could be achieved. We will present the current status as well as proposed first measurements at laser systems.

A 33.5 Thu 16:15 S Fobau Physik

Towards high-repetition rate laser-driven electron rescattering in the molecular frame. — •Federico Branchi, Mark Merö, Marc J.J. Vrakking, Horst Rottke, and Jochen Mikosch — Max-Born-Institut, Berlin

Laser-induced electron diffraction (LIED) is an extension of classical diffraction with electron beams, where the scattering electron is derived from its own molecule by strong-field ionization and accelerated by the oscillating laser field. Since the electron is strongly confined, high current densities can be achieved in the rescattering process. Due to the short de Broglie wavelength and the phase-locking to the cycle of the driving laser, LIED can achieve Ångstrom spatial and attosecond temporal resolution.

While first applications of LIED to the study of molecular dynamics have been reported [1], fundamental aspects, such as the involvement of multiple continua [2], are still under investigation.

Here, we combine a 100 kHz repetition-rate, mid-IR OPCPA laser system at 1550/3100 nm (signal/idler) [3] with a reaction microscope (REMI) to study LIED of polyatomic molecules in the molecular frame. We present the setup and first experimental results.

[1] Wolter et al., Science 354, 308 (2016)
[2] Schell et al., Science Advances 4, eaap8148 (2018)
[3] Merö et al., Opt. Lett. 43, 5246 (2018)

A 33.6 Thu 16:15 S Fobau Physik

Observation of the Dynamics of a Laser Wakefield using Few-cycle Laser Pulses at Short-wave Infrared Wavelengths (SWIR) — •Mingzhuo Li[1], Yinyu Zhang[1,2], Carola Zepter[1,2], Philipp Wustelt[1,2], Slawomir Skruszewicz[1,2], A. Max Sayler[1,2], Alexander Sävert[1,2], Malte C. Kaluza[1,2], and Gerhard G. Paulus[1,2] — [1]Institute of Optics and Quantum Electronics, Jena, Germany — [2]Helmholtz Insitute, Jena, Germany

High-energy particles from accelerators are important tools for probing fundamental structure of matter, such as elementary particles, atoms, molecules and cells. Conventional accelerator facilities, limited by the radio-frequency (rf) technology, require space of kilometers and cost over $ 1 billion. Laser wakefield accelerator (LWFA), a table-top accelerator technology, which is based on charged particles propagation through relativistic wakes produced by intense laser beams can accelerate particles to several GeV [1]. In order to control the acceleration process inside the plasma, it is essential to know the dynamics of the wakefield. The direct observation of the dynamics of the laser wakefield is achieved by using the transverse shadowgraphy, which is probed by few-cycle pulses at 810 nm [2]. Increasing the wavelength of probe pulses but keeping the pulse length in few-cycle regime can probe plasmas with lower densities, which will increase the spatial resolution and the sensitivity. Here, we report on the high-resolution observation of the dynamics of a laser wakefield using few-cycle pulses at SWIR (1800 nm). [1] W. P. Leemans, et. al., Nat. Phys. 2, 696-699 (2006). [2] A. Sävert, et. al., Phys. Rev. Lett. 115, 055002 (2015).

A 33.7 Thu 16:15 S Fobau Physik

Photoelectron Momentum Distributions of Potassium from an Ultrashort Intense Laser Pulse — •Lutz Marder, Daniel M. Reich, and Christiane P. Koch — Institut für Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel (Germany)

We present ab initio simulation results for the Photoelectron Momentum Distributions (PMDs) in potassium atoms obtained in experiments using highly intense linearly polarized femtosecond laser pulses. To model the potassium atom we use a single-active electron approach with a relativistic effective potential. The electronic wave function is represented by spherical harmonics and a radial spatial grid with a Finite Element Discrete Variable Representation (FE-DVR) using Gauß-Legendre-Lobatto (GLL) points. We compare our simulated PMDs with state-of-the-art experiments investigating interesting features observed in the Photoelectron Angular Distribuations (PADs) of potassium.

A 33.8 Thu 16:15 S Fobau Physik

Nanoscale vacuum-tube-typed electronic devices triggered by few-cycle laser pulses — •Constanze Sturm, Takuya Higuchi, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

Electron pulses from a sharp needle tip triggered by ultrashort laser pulses via multiphoton photoemission are extremely confined both in space and time. Employing these electrons as carriers in electronic devices may drastically improve their operational speed.

We present an experiment based on two lithographically fabricated gold tips on top of a fused silica substrate. The two tips facing each other are separated by a fixed distance set between 30 nm and 2 μm. The final tip radius depends on the opening angle chosen for the tips and the dose parameter of the lithography process. Optimizing both results in a minimum tip radius of 15 nm.

In the experiment two tips with different tip radii are illuminated by 6 fs Ti:sapphire laser pulses. Measuring the total current results in a non-vanishing current from the sharper tip to the blunter one. This can be explained by numerical simulations showing a stronger optical near-field enhancement at the sharper tip, resulting in a stronger electron emission. Our goal is to control the electron emission by changing the static field landscape, the incident laser power and the light polarization.

A 33.9 Thu 16:15 S Fobau Physik

Time delay effects in strong field ionization — •Daniel Bakucz Canário, Michael Klaiber, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117, Heidelberg, Germany

The problem of the electron time delay in the tunnel ionization in strong laser fields has received renewed attention following recent experimental results confirming a non-zero time delay[1]. We investigate aspects of time delay in strong fields by using the strong field approximation for a zero-range potential to calculate the time delay (with respect to the laser field peak) of an ionized electron wavepacket and comparing this to the time delay of a Wigner trajectory for a quasi-static barrier as well as a classically evolved trajectory. Our aim is twofold: to show how the time delay and momentum shift of an ionized electron at the tunnel exit counterbalance[2], creating the asymptotically measurable time delay, and secondly, to find a physical interpretation for the emergence of this asymptotic time delay.

[1] N. Camus, E. Yakaboylu, *et al*, Phys. Rev. Lett. 119:023201, Jul 2017.

[2] M. Klaiber, *et al*, Phys. Rev. Lett. 120:013201 Jan 2018.

A 33.10 Thu 16:15 S Fobau Physik

Setup of a high-intensity XUV beamline based on HHG from sub-10-fs NIR pulses — •Björn Senfftleben[1], Mario Sauppe[1], Martin Kretschmar[1], Johannes Tümmler[1], Ingo Will[1], Marc J. J. Vrakking[1,2], Tamás Nagy[1], Bernd Schütte[1], and Daniela Rupp[1] — [1]Max-Born-Institut Berlin, Deutschland — [2]FU Berlin, Deutschland

Intense extreme ultraviolet (XUV) pulses from high-harmonic generation (HHG) have recently started to compete with short-wavelength free-electron lasers in the sense that high-intensity experiments such as nonlinear ionization or single-shot single-particle coherent diffraction imaging can be carried out in the lab. At the same time, the unique characteristics of laser-based HHG sources, namely the high timing control in pump-probe configurations and sub-femtosecond pulse duration, hold the promise for unprecedented experimental possibilities to study ultrafast nanoscale dynamics.

We are currently setting up a high-intensity XUV beamline using sub-10-fs pulses with up to 30 mJ pulse energy from a newly developed thin-disc-laser based optical parametric chirped-pulse amplification (OPCPA) system. First characterization results of the XUV pulses will be discussed.