MO 3: Interaction with Strong or Short Laser Pulses I (joint session A/MO)

Time: Monday 11:00–13:00 Location: F303

Invited Talk MO 3.1 Mon 11:00 F303

Time-resolved Kapitza-Dirac effect — •Kang Lin, Maksim Kunitski, Sebastian Eckart, Alexander Hartung, Qinying Ji, Lothar Schmidt, Markus Schöffler, Till Jahnke, and Reinhard Dörner — Goethe University

The Kapitza-Dirac effect describes that that an electron beam can be diffracted when passing through a light standing wave. In analogy to optical diffraction, the incident electron beam behaves like a wave, while the light standing wave plays the role of the grating. The Kapitza-Dirac effect serves as an optical diagnosis of the electron property in frequency domain. However, with the advent of pulsed laser technique, the ultrafast time information is imprinted in both the electron wavepacket and the light standing wave. It is totally unclear how an electron wavepacket will be diffracted by an ultrafast light standing wave. Here, a principle new phenomenon, termed as time-resolved Kapitza-Dirac effect, is discovered. We track the spatiotemporal evolution of an electron wavepacket diffracted by an ultrafast femtosecond (10-15 seconds) light standing wave. By scanning the time delay between the electron wavepacket and the standing wave, we observe so far unseen quantum interference effects. We show that the momentum spacing between diffraction peaks decreases continuously with the time delay increasing, which can be fractions instead of multiply integers of 2-photon momenta. The time-resolved Kapitza-Dirac effect can directly measure the chirp of the electron wavepacket optically.

MO 3.2 Mon 11:30 F303

Laser-Driven Acceleration of Gold Ions — •Laura Desiree Geulig, Erin Grace Fitzpatrick, Maximilian Weiser, Veronika Kratzer, Vitus Magin, Masoud Afshari, Jörg Schreiber, and Peter G. Thirolf — Ludwig-Maximilians-Universität München

The efficient acceleration of gold ions is a first step towards the 'fission-fusion' reaction mechanism, which aims at investigating the rapid neutron capture process in the vicinity of the N=126 waiting point [1]. In our recent measurement at the PHELIX laser with a pulse length of 500fs, for the first time, the laser-based acceleration of gold ions above 7 MeV/u was demonstrated. Additionally, individual gold charge states were resolved with unprecedent resolution [2]. This has allowed the investigation of the role of collisional ionization using a developmental branch of the particle-in-cell simulation code EPOCH [3], showing a much better agreement of the simulated charge state distributions with the experimentally measured ones than when only considering field ionization. This work is continued at the Centre for Advanced Laser Applications (CALA), using the ATLAS3000 laser (800nm central wavelength, 25 fs pulse length).

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011)
[2] F.H. Lindner et al., Sci. Rep. 12, 4784 (2022)
[3] M. Afshari et al., Sci.Rep. 12, 18260 (2022)

MO 3.3 Mon 11:45 F303

Transfer learning and visualization of a convolutional neural network for recognition of the internuclear distance in a molecule from electron momentum distributions — •Nikolay Shvetsov-Shilovski and Manfred Lein — Leibniz Universität Hannover

We use a convolutional neural network (CNN) to retrieve the internuclear distance in the two-dimensional H_2^+ molecule ionized by an intense few-cycle laser pulse from the photoelectron momentum distributions [1]. We study the effect of the carrier-envelope phase on the retrieval of the internuclear distance with a CNN [2]. By using the transfer learning technique, we make our CNN applicable to momentum distributions obtained at the parameters it was not explicitly trained for. We compare the CNN with alternative approaches that are shown to have very limited transferability. Finally, we use the occlusion sensitivity technique to extract features of the momentum distributions that allow a CNN to predict the internuclear distance.

[1] N. I. Shvetsov-Shilovski and M. Lein, Phys. Rev. A, 105, L021102 (2022).
[2] N. I. Shvetsov-Shilovski and M. Lein, submitted to Phys. Rev. A, arXiv:2211.01210.

MO 3.4 Mon 12:00 F303

Holographic Single-Shot Imaging and Reconstruction of ultrafast laser-driven dynamics in thin films — •Richard Altenkirch, Franziska Fennel, Christian Peltz, Thomas Fennel, and Stefan Lochbrunner — Institute of Physics, Universität Rostock, Germany

Well controlled laser material processing with a spatial resolution on the scale of the laser wavelength is significant to a large variety of both research and industrial applications. A full characterization of the spatial and temporal evolution of the ultrafast laser-induced plasma dynamics will be key to future developments in the respective fields. So far, the established diagnostic methods are mostly sensitive to the target absorption and luminescence. Here, we present an experimental and numerical approach based on coherent diffractive imaging (CDI), a technique well known from free particle characterization at XFEL's [1], also providing access to the phase delay caused by the target. In a two-color pump-probe experiment, a thin film is excited by a short pump pulse and the resulting plasma dynamics are imaged by a frequency doubled probe pulse. The corresponding complex near field behind the target is reconstructed from the recorded scattering image via a phase retrieval approach [2]. We also present a thorough characterization of the method and a first successful application to experimental data.

[1] H. Chapman et al., Nature Physics **2** 839-843 (2006)
[2] J. Fienup, Appl. Opt. **21**, 2758-2769 (1982)

MO 3.5 Mon 12:15 F303

Modeling controlled sub-wavelength plasma formation in dielectrics — •Jonas Apportin, Christian Peltz, Björn Kruse, Benjamin Liewehr, and Thomas Fennel — Institute for Physics, Rostock, Germany

Laser induced damage in dielectrics due to short pulse excitation plays a major role in a variety of scientific and industrial applications, such as the preparation of 3D structured evanescently coupled waveguides [1]. Here the irreversible modifications originate from higher order nonlinearities like strong field ionization and plasma formation. Improving user control over these material modifications, e.g. permanent refractive index modifications, therefore strongly relies on a better understanding of the underlying interaction dynamics, in particular the early phases of interaction. To this end we developed and utilized a numerical model, that combines a local description of the dynamics in terms of corresponding rate equations for ionization, collisions and heating with a fully electromagnetic field propagation via the Finite-Difference-Time-Domain method, adding self-consistent feedback effects like the sudden buildup of plasma mirrors. Here we present first numerical results regarding the creation and control of sub-wavelength gratings formed at the rear side of fused silica films.

[1] D. Blömer et al., Opt. Express 14, 2151-2157 (2006)

MO 3.6 Mon 12:30 F303

Ultrafast two-electron correlations from metal needle tips — •Jonas Heimerl, Stefan Meier, and Peter Hommelhoff — Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen

When two electrons are emitted in a very confined space-time volume on the nanometer-femtosecond scale, strong Coulomb interaction is present. With the advent of multi-hit capable electron detectors, the field of ultrafast light matter interaction around metal needle tips is venturing into correlated multi-electron dynamics. Here we show the Coulomb-induced energy anti-correlation of two electrons emitted from nanometer-sized tungsten needle tips triggered by femtosecond laser pulses [1]. We extract two important key parameters: (1) the mean energy splitting of 3.3 eV and (2) the correlation decay time of 82 fs. Both parameters are essential for modern ultrafast electron microscopes, as shown in similar work from the Göttingen group [2]. We demonstrate that by filtering the electrons energetically, clear sub-Poissonian distributed electron beams can be achieved, highly relevant for beating the shot-noise limit in imaging applications. Furthermore, we show that in the strong field regime, where ponderomotive effects of the laser field become important, the anti-correlation gap is strongly influenced.

[1] S. Meier, J. Heimerl and P. Hommelhoff, arXiv:2209.11806 (2022)
[2] R. Haindl et al., arXiv:2209.12300 (2022)

MO 3.7 Mon 12:45 F303

Testing Born's rule via photoionization of helium — •Peter Robert Förderer[1], David Busto[1,2], Anne L'Huillier[2], Andreas Buchleitner[1,3], and Christoph Dittel[1,3,4] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]Department of Physics, Lund University, Box 118, 22100 Lund, Sweden — [3]EUCOR Centre for Quantum Science and Quantum Computing, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [4]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität Freiburg, Albertstraße 19, 79104 Freiburg, Germany

We propose a protocol to test Born's rule (a fundamental axiom of quantum mechanics) via the Sorkin test, applied to photoionization of helium, induced by the combination of an ultrashort extreme ultraviolet pulse with a trichromatic infrared laser pulse. We numerically simulate the outcome of the Sorkin test, the Sorkin parameter κ, for realistic parameters and randomly sampled, typical experimental imperfections. The latter do not only lead to a spread, but also to a systematic offset of κ from its ideal value $\kappa = 0$. A determination of κ with an achievable precision of the order $10^{-3} - 10^{-4}$ is predicted, which is comparable to the precision of 10^{-3} reached in the best optical experiments [Kauten, et. al., New J. Phys. 19, 033017 (2017)] in the quantum regime.