K 2: Poster

Time: Tuesday 16:30–18:30 Location: P

K 2.1 Tue 16:30 P

Extreme self-regulation in high-harmonic generation — •Evaldas Svirplys[1], Katalin Kovács[2], Muhammad Anus[1], Omair Ghafur[1], Katalin Varjú[3,4], Marc J. J. Vrakking[1], Valer Tosa[2], Balázs Major[3,4], and Bernd Schütte[1] — [1]Max-Born-Institut, Berlin, Germany — [2]National Institute for Research and Development of Isotopic and Molecular Technologies, Cluj-Napoca, Romania — [3]ELI-ALPS, Szeged, Hungary — [4]Department of Optics and Quantum Electronics, University of Szeged, Szeged, Hungary

We present a novel High-harmonic generation (HHG) scheme that shows extreme self-regulation of the driving laser intensity. Near-infrared (NIR) laser pulses are focused into a high-pressure atomic jet, leading to intensities of about 10^{16} W/cm^2, which is much higher than the optimal intensity for HHG. Substantial Spectral reshaping of the NIR 50-fs laser pulse was observed in each atomic species investigated (Xe, Kr, Ar, Ne, He), resulting in the observation of a ten-fold increase of the initial NIR bandwidth. Our experimental and numerical study shows that ionization-induced self-phase modulation is responsible for the spectral broadening, while plasma-induced defocusing results in a substantial decrease and self-regulation of the NIR intensity. This allows for the build-up of phase-matched HHG and results in the generation of continuous spectra ranging from 18-140 eV albeit using long driving laser pulses. This flexible and compact HHG scheme is ideally suited for absorption spectroscopy, allowing to access different spectral ranges without the need for tedious optimization procedures.

K 2.2 Tue 16:30 P

Attosecond streaking of an infrared parametric waveform synthesizer — •Fabian Scheiba[1,2,3], Giulio Maria Rossi[1], Roland E. Mainz[1], Miguel A. Silva-Toledo[1,3], Yudong Yang[1], Phillip D. Keathley[4], Giovanni Cirmi[1,2], and Franz X. Kärtner[1,2,3] — [1]Center for Free-Electron Laser Science CFEL and Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Universität Hamburg, Fachbereich Physik, Jungiusstraße 9, 20355 Hamburg — [4]Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

Attosecond streaking measurements provide the temporal information of both, the ionizing XUV pulse and the infrared streak field. The method is utilized to characterize >1.5 octave spanning infrared (IR) waveforms as generated by our parametric waveform synthesizer and at the same time to characterize the isolated attosecond pulse (IAP) continua as generated via high harmonic generation (HHG) in gases. Here, a near-IR ((0.65-0.95) μm) and IR ((1.2-2.2) μm) spectral channel with a relative phase stability of 70 mrad are synthesized, resulting in a sub-cycle pulse of 1.4 μm central wavelength. Attosecond streaking measurements prove the excellent long-term pulse-to-pulse stability as well as versatility in shaping the synthesized waveforms to non-sinusoidal fields in the sub-cycle limit that in return allows for controlling the IAP in bandwidth and central energy in a single focussing geometry.

K 2.3 Tue 16:30 P

Generation of VUV radiation from two-color laser setup for nuclear spectroscopic measurements on thorium — •Kuldeep Singh Karda, Philip Mosel, Pranitha Sankar, Elisa Appi, Uwe Morgner, and Milutin Kovacev — Institut für Quantenoptik, Cluster of Excellence PhoenixD and QuantumFrontiers, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

The Thorium-229 nucleus is known to possess an isomeric state at an energy of about 8 eV above the ground state, several orders of magnitude lower than typical nuclear excitation energies [1]. Owing to the lower energy the 229Th isomer is accessible to resonant laser excitation. A main experimental challenge is to drive this nuclear excitation resonantly with a narrow-band laser [1]. However, exact knowledge of this energy level is crucial for laser spectroscopy and for the development of optical nuclear clocks. This problem could be overcome by using a tunable laser system in the vacuum ultraviolet (VUV) spectral range. In the presented work, VUV radiation between 140 and 160 nm is efficiently generated by using two-color frequency mixing of different laser modes inside gas-filled capillary. This technique allows to enhance the conversion efficiency of a tunable Ti:Sapphire laser system in the VUV. The presented setup can fulfill the requirements of a narrow-band light source for direct laser excitation laser applying schemes like internal conversion electron-Mössbauer spectroscopy (CEMS) in thin layer of neutral 229Th atoms[2].

[1] K.Beeks et al., Nature. Rev. Phys. 3, 238-248 (2021).
[2] L. von der Wense et al., Phys. Rev. Lett. 119, 132503 (2017).

K 2.4 Tue 16:30 P

Radiation from Electron - Laser Pulse Collisions — •Michael Quin, Antonino Di Piazza, Christoph H. Keitel, and Matteo Tamburini — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

The collision of relativistic electrons with a laser pulse can potentially generate short pulses of X-rays, capable of tracking molecular, atomic and sub-atomic dynamics. We consider how the spectrum and angular distribution of radiation emitted varies with the initial position and momentum of electrons colliding with a plane wave pulse, in the domain of Classical Electrodynamics. This informs how we can customise the radiation spectrum, which can be verified with simulations involving a focused laser pulse and realistic electron distribution.

K 2.5 Tue 16:30 P

A 100-kHz, high-brightness ultrafast electron diffraction set-up for sub-100-fs structural dynamics — •Fernando Rodriguez Diaz, Mark Meroe, Marc Vrakking, and Kasra Amini — Max Born Institute, Berlin, Germany

Photo-induced chemical reactions and phase transitions in gas-phase molecules and solid-state structures play an important role in biological processes and photoelectronics, such as photo-isomerization and photovoltaics. Such photo-induced processes occur on the few hundreds-to-thousands of femtoseconds timescale, with changes in the position of atoms in the molecular or lattice structure occurring on the sub-Angstrom spatial scale. So far, ultrafast electron diffraction (UED) has been utilized to visualize and track in real-time the structural dynamics of photo-induced reactions with sub-Å and sub-300-fs resolution. However, the temporal resolution of state-of-the-art UED set-ups, which operate at less than 5-kHz, is not sufficient to time-resolve some rapidly evolving photo-induced processes (e.g. <500-fs timescale of photo-isomerization). Here, we present a 100-kHz, 100-kV UED set-up recently built and commissioned at the Max-Born Institute, Berlin. Our set-up will be capable of operating in high-bunch charge single-shot mode (i.e. up to 1E6 electrons/pulse) or low-bunch charge high temporal resolution mode (i.e. less than 1E3 electrons/pulse) at 100-kHz. Using our set-up, we anticipate time-resolved measurements of photo-induced structural dynamics in solid-state and gas-phase systems with sub-Å spatial and sub-100-fs temporal resolution, which will go beyond the current state-of-the-art in UED.

K 2.6 Tue 16:30 P

Quantum coherent control of free electron wavefunction using ponderomotive potencial of optical travelling waves — •Kamila Moriová and Martin Kozák — Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

Inelastic interactions between free electrons and photons have been studied extensively during the last few years. In this contribution, we describe theoretically the interaction of electrons with ponderomotive potential of optical travelling waves formed by two light waves at different frequencies in vacuum. Our current effort follows up previous experiments performed in the classical regime of the interaction, which showed the electron spectrum broadening and attosecond electron pulses generation as a result of the interaction [1], [2]. We describe how these experiments can be modified to allow quantum coherent optical modulation of the phase of electron wavefunction. [1] Kozák, M. et al. Nat. Phys. 14, 121-125 (2018), [2] Kozák, M. et al. Phys. Rev. Lett. 120, 103203 (2018)

K 2.7 Tue 16:30 P

Single-shot multi-frame shadowgraphy in laser-plasma interactions via sequentially timed all-optical mapping photography (STAMP) — •Yu Zhao, Daniel Ullmann, and Alexander Sävert — Helmholtz Institute Jena, Germany

Ultrafast shadowgraphy with transverse few-cycle transverse probe pulses enabled direct observation of laser-plasma interactions, which has been achieved femtosecond temporal and micrometer spatial resolution. However, in previous studies, only one shadowgram was captured from each of the laser-plasma interaction processes. Nevertheless, the shot-to-shot fluctuation of a high-power laser system is not negligible. This limits our understanding of laser-plasma interaction processes. In this study, we introduce a single-shot multi-frame shadowgraphy technique based on sequentially timed all-optical mapping photography (STAMP). The probe is seeded by a fraction of pump laser energy and coupled into a rare gas-filled hollow-core fiber to be spectrally broadened by self-phase modulation. Then the probe is temporally compressed to reach its Fourier limit pulse duration (few-fs) via chirped mirrors and glass wedges. Next, the few-femtosecond probe is linearly frequency-chirped via a glass rode, temporally stretched up to ∼100 fs. After the probe propagates through the interaction area, it is imaged by a microscopic imaging system, then separated into five replicas via a diffractive beam splitter. Five different narrow bandpass filters (10 nm, FWHM) are placed in front of the CCD camera to capture five frames that correspond to different time delays from a laser-plasma interaction with a sub-10 fs temporal resolution.

K 2.8 Tue 16:30 P

Precise diagnostic of high-power ultra-short laser — •Xinhe Huang[1,2,4], Alexander Sävert[1], Beate Heinemann[2,4], and Matt Zepf[1,3] — [1]Helmholtz Institute Jena, Jena, Germany — [2]DESY, Hamburg, Germany — [3]Friedrich Schiller Universität Jena, Jena, Germany — [4]Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

The LUXE (Laser Und XFEL Experiment) project aims to measure processes in the strong-field quantum electrodynamics regime with high precision by colliding electrons or a high-energy photon beam with high-power, tightly focused laser beam at a repetition rate of 1Hz. Simulations [1] predict that the probability of pair production responds highly non-linearly to the laser strength parameter. Consequently, small variations in the laser intensity lead to significant variations in the experimental observables. The required precision will be achieved by intensity tagging though precise measurements on the relative variation of intensity on a shot-by-shot basis. We present results of a laser diagnostic system performed on the JETI200 laser, with an ultimate aim to monitor the shot-to-shot fluctuations with precision below 1%.

[1] LUXE CDR, arXiv:2102.02032 [hep-ex]

K 2.9 Tue 16:30 P

Towards rapidly-tunable, femtosecond UV laser pulses — •Fridolin Geesmann[1,2], Robin Mevert[1,2], Yuliya Binhammer[1,2], Christian M. Dietrich[1,2], Luise Beichert[1,2], José R. Cardoso de Andrade[3], Thomas Binhammer[4], Jintao Fan[1,2], and Uwe Morgner[1,2] — [1]Institute of Quantum Optics, Leibniz University Hannover, Welfengarten 1, D-30167 Hannover, Germany — [2]Cluster of Excellence PhoenixD, Welfengarten 1, D-30167 Hannover, Germany — [3]Max-Born-Institute, Max-Born-Straße 2A, D-12489 Berlin — [4]neoLASE GmbH, Hollerithallee 17, D-30419 Hannover, Germany

Optical parametric oscillators allow the generation of femtosecond, widely tunable radiation with high output power. This makes them a perfect tool for spectroscopy or imaging. Here, we show theoretical considerations for the generation of tunable UV radiation using intracavity processes in such a noncollinear optical parametric oscillator that provides fast tunable radiation in the visible spectral region from 440-720 nm. Two different conversion processes can be used for this purpose. First, an intracavity second harmonic generation process can be used to cover a wide range in the UV. However, this method has the disadvantage that the converted wavelength is selected by changing the crystal angle, which allows only slow tuning speeds. Therefore, an additional method is being investigated, which should enable fast tuning of the generated radiation by changing the cavity length only. This can be achieved via a non-collinear sum frequency generation process, but has the disadvantage that only the near UV region can be reached.

K 2.10 Tue 16:30 P

Electron-Lattice Relaxation Time Dynamics and Separation Time Dynamic of Multiple Pulses Femtosecond Laser Ablation Process on Gold. — •Hardik Vaghasiya[1,2], Stephan Krause[1,2], and Paul-Tiberiu Miclea[2,1] — [1]Martin Luther University Halle-Wittenberg, ZIK Sili-nano, Halle, Germany — [2]Fraunhofer Center for Silicon Photovoltaics CSP, Germany

To study the ultrashort laser pulse interaction on gold, a set of coupled partial differential equations of the two-temperature model was solved in the spatial and time domains with dynamic optical properties and phase explosion mechanism. In an extended Drude model considering interband transitions, the reflectivity and absorption coefficient are contemplated based on the electron relaxation time. The laser energy deposition and phase explosion ablation mechanism are analyzed in the case of succession of fs-laser pulses (180 fs, 1030 nm) on gold with experimental results. The simulation results demonstrate that by increasing the number of pulses with a shorter separation time compared to electron-lattice relaxation time, lattice temperature can be considerably increased without a noticeable increase in ablation depth. In the study of multiple pulses fs laser ablation, the computational model indicates that succession of laser pulses with a pulse separation time of 50 ps or longer can significantly boost the ablation rate at the same laser fluence. Thus, the deviation from experimental and simulation results gives rise to the conclusion that temporal pulse manipulation with separation time greater than the electron-lattice relaxation time is a useful technique for fast femtosecond laser processing.

K 2.11 Tue 16:30 P

Ultra-short laser micro-machining by spatially shaped ps- and fs-pulses for depth-selective μ-TLM resistivity test structures of sputter-deposited metal/oxid/semiconducting contact layers — •Stephan Krause[1,2], Stefan Lange[2], Hardik Vaghasiya[1], Christian Hagendorf[2], and Paul-Tiberiu Miclea[2,1] — [1]Centre for Innovation Competence SiLi-nano, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany — [2]Fraunhofer Center for Silicon Photovoltaics CSP, Halle (Saale), Germany

In this work, we applied spatially shaped ultra-short pulse laser micromachining for a new processing approach of μ-TLM test structures. These structures are used for resistivity measurements of multilayer systems with highly resistive interface layers, e.g. in oxide passivation layers for solar cells. For precise measurements of electrical sheet and contact resistivity of the individual layers, isolating trenches and homogenous ablation areas are required. Ultrashort pulses with 10 ps and 200 fs of different laser wavelength (532 nm, 1030 nm) as well as optical beam shaping elements for a redistribution of the intensity from gauss to top-hat profiles enables a selective removal of top metallic Ag and oxide layers on the multilayer stack. At the same time thermal damage is minimized in underlying material and adjacent region of the laser trenches. Small effective optical penetration and sub μm-adjustable ablation depth were achieved by an ultrafast ablation mechanism via absorption at the several multilayer interfaces. Morphology and microstructure of heat affected zones (HAZ) at the laser structures are characterized by scanning electron microscopy.

K 2.12 Tue 16:30 P

Orthogonally Superimposed 3D Laser-Induced Periodic Surface Structure (LIPSS) upon Femtosecond Laser Pulse Irradiation of Silicon surface for Surface Enhanced Raman Scattering (SERS) application. — •Hardik Vaghasiya[1,2], Stephan Krause[1,2], Christian Hagendorf[2], and Paul-Tiberiu Miclea[2,1] — [1]Martin Luther University Halle-Wittenberg, ZIK Sili-nano, Halle, Germany. — [2]Fraunhofer Center for Silicon Photovoltaics CSP, Germany.

We report on the generation of homogenous low spatial frequency LIPSS on crystalline silicon with beam-shaped femtosecond pulsed laser irradiation at 1030 nm wavelength. Three-dimensional laser-induced periodic surface structures with pattern sizes periodicity around laser wavelength are obtained on the silicon surfaces. The distinctive orthogonally superimposed 3D LIPSS is achieved by employing a double step technique that relies on irradiation with two temporally delayed and cross-polarized femtosecond-laser pulses. In silicon, orthogonally superimposed 3D LIPSS structure of a few nanometers to micron in amplitudes were produced over a larger area, and the influence of the applied laser fluence, pulse overlap, and angle of incidence on the periodic surface structures are investigated. The periodicity and amplitude of 3D LIPSS can be tuned by controlling the number of pulses irradiation and applied laser fluence. Finally, this work presents novel, multi-scale periodic patterns with three-dimensional symmetry generated on the silicon surface, for sensor application, e. g. SERS-substrates.

K 2.13 Tue 16:30 P

Generation of Nanoparticle for Investigation of Laser Induced Transfer — •Jannik Wagner, Philip Mosel, Pranitha Sankar, Elisa Appi, Uwe Morgner, and Milutin Kovacev — Institute of

Quantum Optics, Cluster of Excellence PhoenixD and Quantum Frontiers, Leibniz Universität Hannover, Hannover, 30167, Germany

Nanoparticles are used for microfabrication technologies that enable controlled deposition of a wide variety of materials.[1] There are two established methods for nanoparticle generation: laser-induced forward transfer (LIFT) and laser-induced backward transfer (LIBT). These methods differ primarily in the direction in which the particle is ejected relative to the laser propagation. The laser pulse heats the metal donor substrate and forms a bubble of liquid metal due to surface tension. The collapse of the bubble produces a spherical nanoparticle.[2]

In this work, single particles with size <5 um are generated using a pulsed ns laser system in LIBT and LIFT configuration. The change of particle size with photon flux and varied laser focus position is investigated. In addition, the formation of the particles is optically tracked and imaged.

[1] Zacharatos et al., Optics & Laser Technology 135: 106660 (2021)
[2] Kuznetsov et al., Appl. Phys. A 106, 479-487 (2012)

K 2.14 Tue 16:30 P

Towards studying collective effects in laser-driven heavy ion acceleration — •Erin G. Fitzpatrick, Laura Geulig, Maximilian Weiser, Florian H. Lindner, and Peter G. Thirolf — Ludwig-Maximilians-Universität München, Germany

Laser accelerated ion bunches offer unique properties, like an ultrahigh, almost solid-state density. This may affect their stopping behavior in matter via collective effects and ultimately enable to establish new nuclear reaction schemes like the 'fission-fusion' mechanism, aiming to generate astrophysically relevant, extremely neutron-rich isotopes near N=126. Two major prerequisites are needed for the realization of this reaction mechanism: (i)Laser-driven heavy ion bunches at energies above their fission barrier (7 MeV/u for ^{232}Th) with (ii)extremely high bunch densities. Experimental campaigns at different PW class laser facilities resulted in the acceleration of gold ions to maximum kinetic energies beyond 7 MeV/u and ion bunch densities of about 10^{13} cm^{-3} (10^{16} cm^{-3}) at 1 mm (100 μm) from the target.

At the Center for Advanced Laser Applications (CALA) in Garching we are preparing for studies to investigate collective effects, like a potential reduction of the stopping power of heavy laser-accelerated ion bunches in solid targets. They will be assessed via the energy deposition of accelerated ion bunches in solid targets placed closely downstream of the acceleration target. An overview of the project and its status will be given. This project is funded by BMBF [05P2018WMEN9].

K 2.15 Tue 16:30 P

Laser-driven proton acceleration based on expanded thin target — •Mingyuan Shi[1,2], Peter Hilz[1], Israa Salaheldin[1,2], Bin Liu[1], Bifeng Lei[1,2], Alexander Saevert[1,2], Georg Schaefer[1,2], and Matt Zepf[1,2] — [1]Helmholtz-Institute Jena, Jena, Germany — [2]Friedrich-Schiller-Universität Jena, Jena, Germany

With the development of ultra-fast and ultra-short laser technology, the interaction between femtosecond laser and matter has aroused people's great attention. Regarding to laser-ion acceleration, the ions are accelerated to relativistic velocity within a few optical cycles is still a challenge due to technical limitations and cost to date. But laser-based proton and ion acceleration has already demonstrated outstanding potential in beam divergency, acceleration gradient and beam duration[1,2].

In principle the near critical density plasma can deposit more laser energy[3], therefore increasing the energy of accelerated particle. But a controllable plasma density to solid target experiment is still a challenge up to date. Here we try to produce a controllable plasma near critical density and based on it to investigate the plasma density effect to ion acceleration. In particular we aim to diagnose the evolution of plasma maximum density after pre-pulse shooting. Investigating the optimum plasma density to the proton acceleration. At the same time the back reflection light will be collected bring rich information.

[1] Hegelich, et al. Nature 439.7075 (2006): 441-444. [2] Gaillard, et al. Physics of Plasmas 18.5 (2011): 056710. [3] Sharma, et al. Scientific reports 9.1 (2019): 1-10.

K 2.16 Tue 16:30 P

Enhancement of X-ray generation by ultrashort-pulsed laser-material interaction — •Patrick Markus Rössler, Philip Mosel, Pranitha Sankar, Elisa Appi, Uwe Morgner, and Milutin Kovacev — Institut für Quantenoptik, Cluster of Excellence PhoenixD and Quantum Frontiers, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

Nowadays a large range of ultrashort-pulsed laser systems are able to reach intensities above 10^{13} W/cm^2 and can easily ignite a plasma on a solid target-sample. The laser-induced plasma can be used as a source of incoherent X-ray radiation [1]. Here, by focusing ultrashort laser-pulses on a rotating metallic cylinder under vacuum conditions, measurements of the photon flux and the spectrum in the range of 2 keV to 20 keV with a calibrated detector Silix lambda are shown [2]. In addition, the interaction between different pulses and heat accumulations effects are able to change the plasma dynamics which can lead to an increase of the generated X-ray photon flux. In the presented work, double pulse and burst-mode like schemes are investigate in order to enhance the X-ray generation and manipulate the spectral emission.

[1] Martín, L., et al. "Improved stability of a compact vacuum-free laser-plasma X-ray source" High Power Laser Science and Engineering, 2020
[2] Mosel, P., et al. "X-ray Dose Rate and Spectral Measurements during Ultrafast Laser Machining Using a Calibrated (High-Sensitivity) Novel X-ray Detector" Materials, 2021

K 2.17 Tue 16:30 P

Torus-knot angular momentum in bicircular high-harmonic generation — •Björn Minneker[1,2,3], Birger Böning[2,3], Anne Weber[1], and Stephan Fritzsche[1,2,3] — [1]Theoretisch Physikalisches Institut, Friedrich-Schiller-Universität, Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]Helmholtz Institut, Jena, Germany

We provide a model which demonstrates intuitively the conservation of the torus-knot angular momentum (TKAM) in bicircular high-harmonic generation and describes where it maid be found in the process. In addition, we discuss how topological non-trivial features can be formed from bicircular driving beams and the associated high-harmonic radiation. The topological non-triviality is a unique property that can not be seen in high harmonic generation by single beam configurations. In general, the topological non-trivial features of the harmonic radiation can be interesting for spectroscopy since topological structures are often robust with regard to various ambient conditions. However, to demonstrate these suggestions further investigations are necessary. Therefore, our work provides a different approach to thinking and speaking about high harmonic generation driven by bicircular twisted light beams.