A 6: Attosecond Physics I (joint session A/MO)

Time: Tuesday 11:00–12:30 Location: GrHS Mathe

Invited Talk A 6.1 Tue 11:00 GrHS Mathe

Water Window HHG continua driven by sub-cycle, nonsinusoidal IR Pulses — •Fabian Scheiba[1,2,3], Miguel Silva[1,2], Giulio Maria Rossi[1,3], Roland E. Mainz[1,2,3], Maximilian Kubullek[1,2], Rafael d. Q. Garcia[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]Physics Department, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

We present the next milestone of our infrared (IR) Parametric Waveform Synthesizer (PWS), that is the generation of HHG continua in the Water Window (WW) spectral region, up to 450 eV. The IR driver pulses are characterized to a pulse duration of 2.8 fs at 1.6 μm central wavelength and an update of the attosecond beamline apparatus enables for high pressure phase matching in Helium and Neon gases. The PWS allows for sub-cycle control of the HHG process and following control of the HHG spectra. Scans of the given phase parameters of the driving electric field show a strong dependence of the generated HHG and therefore unmatched tuning capabilities. Furthermore, calibrated measurements of the HHG yield allows us to claim a significant efficiency increase comapared to a few cycle sinusoidal driver pulse.

A 6.2 Tue 11:30 GrHS Mathe

Towards AI-enhanced online-characterization of ultrashort X-ray free-electron laser pulses — •Thorsten Otto[1,2,4], Kristina Dingel[2], Lars Funke[3], Sara Savio[3,4], Lasse Wülfing[3,4], Bernhard Sick[2], Wolfram Helml[3], and Markus Ilchen[1,4] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [2]University of Kassel, Intelligent Embedded Systems, Wilhelmshöher Allee 73, 34121 Kassel, Germany — [3]Technische Universität Dortmund, Fakultät für Physik, Maria-Göppert-Mayer-Straße, 44227 Dortmund, Germany — [4]Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149 22761 Hamburg

X-ray free-electron lasers provide ultrashort X-ray pulses with durations typically in the order of femtoseconds, but recently even entering the attosecond regime. The technological evolution of XFELs towards well-controllable light sources for precise metrology of ultrafast processes can only be achieved using new diagnostic capabilities for characterizing X-ray pulses at the attosecond frontier. The spectroscopic technique of photoelectron angular streaking has successfully proven how to non-destructively retrieve the exact time-energy structure of XFEL pulses on a single-shot basis. By using deep learning algorithms, we show how this technique can be leveraged from its proof-of-principle stage towards routine diagnostics at XFELs providing precise feedback in real time.

A 6.3 Tue 11:45 GrHS Mathe

Extracting RABBITT-like phase information from time dependent transient absorption spectra — •Julian Jakob[1], Cornelia Bauer[1], Murat-Jakub Ilhan[1], Divya Barthi[2], Christian Ott[2], Thomas Pfeifer[2], Klaus Bartschat[3], and Anne Harth[1] — [1]Center for Optical Technologies, Aalen University, Aalen, Germany — [2]Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany — [3]Department of Physics and Astronomy, Drake University, Des Moines, IA 50311, USA

We investigate transient absorption spectroscopy by exploring how the spectral phase of the attosecond pulse train modulates the optical density signal. The process is driven by the interaction of extreme ultraviolet (XUV) and near-infrared (NIR) fields, with their relative time delay playing a crucial role in shaping the dynamics [1]. As demonstrated in Reconstruction of Attosecond Beating by Interference of Two-Photon Transitions (RABBITT) experiments, the XUV phase can be measured by examining the photoionization electron spectrum as a function of the time delay between the XUV and NIR fields [2]. Similarly, the spectral phase of the XUV field imprints itself in oscillations of the optical density, which occur at twice the NIR frequency ($2\omega_{\mathrm{NIR}}$). Using a few-level model, we simulate the quantum dynamics and validate our findings by solving the time-dependent Schrödinger equation (TDSE) for atomic hydrogen. This approach reveals how the spectral phase modulates the optical density, thereby providing a direct link to the underlying attosecond electron dynamics. [1] Holler, Phys. Rev. Lett. 106, 123601 (2011), [2] Hentschel, Nature 414, 509-513 (2001)

A 6.4 Tue 12:00 GrHS Mathe

In silico approach for understanding experimental sub-cycle driven high harmonic generation from XUV to soft X-rays. — •Rafael de Q. Garcia[1,2], Maximilian Kubullek[1,2], Miguel Silva[1,2], Roland E. Mainz[1,2,3], Fabian Scheiba[1,2,3], Giulio M. Rossi[1,3], 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]Physics Department, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

High harmonic generation (HHG) has since long been used for generating tabletop XUV to soft X-ray isolated attosecond pulses used for ultrafast science. However, as the pulses driving HHG get shorter, achieving even sub-cycle duration, new challenges are faced both experimentally and theoretically to understand which electric field is producing HHG and how phase-matching of HHG actually happens in a medium. To answer these questions, we combine an in situ pulse characterization technique with a 1D optical and HHG-field propagation code. With these two tools, we simulate the outcomes of an experiment performed with our parametric waveform synthesizer, which drives HHG with either few-cycle or synthesized sub-cycle pulses, under different macroscopic conditions. It is shown, that this method enables qualitative and quantitative agreement between experiment and simulation, answering fundamental questions about sub-cycle driven HHG such as efficiency increase and plasma propagation effects.

A 6.5 Tue 12:15 GrHS Mathe

The Quantum Superluminality of Tunnel-ionization — •Ossama Kullie — University of Kassel, Institute of Physics

In our tunnel-ionization model presented in previous work[1,2,3,4], we showed that adiabatic and nonadiabatic tunnel-ionization time amounts to determine the barrier time-delay with good agreement with the attoclock measurement and that it corresponds to the dwell time and the interaction time. In the present work, we show that the barrier time-delay for H-like atoms with large nuclear charge can be superluminal (quantum superluminality), which can be validated experimentally using the attoclock scheme. We discuss the quantum superluminality for the different experimental calibrations of the attoclock. [1] O. Kullie, submitted to J. Phys. Comm. (2024). [2] Ossama Kullie and Igor Ivanov, Ann. of Phys 464, 169648 (2024). [3] O. Kullie, Phys. Rev. A 92, 052118 (2015). [4] O. Kullie. J. Phys. Commun. 2 065001 (2018).