A 2: Interaction with strong or short laser pulses I

Time: Monday 14:00–15:15 Location: A-H1

Invited Talk A 2.1 Mon 14:00 A-H1

Attosecond pulse control with sub-cycle, infrared waveforms
— •Miguel Angel Silva-Toledo[1,3], Yudong Yang[1], Roland E. Mainz[1], Giulio Maria Rossi[1], Fabian Scheiba[1,2,3], Phillip D. Keathley[4], Giovanni Cirmir[1,2], and Franz X. Kärtner[1,2,3] — [1]Center for Free-Electron Laser Science CFEL and Deutsches Elektronen-Synchrotron DESY, Notkestrasse e 85, 22607 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Physics Department, Universität Hamburg, Jungiusstrasse 9, 20355 Hamburg — [4]Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA

Sub-femtosecond shaping of light fields driving high-harmonic generation (HHG) allows amplitude- and phase-control of coherent extreme ultraviolet and soft X-ray radiation. Here, we experimentally demonstrate such control in the energy range covering $\sim$ 30 - 200 eV using tailored, sub-cycle pulses (i.e., shorter than their main oscillation period), delivered by an optical parametric amplification-based waveform synthesizer. Sub-cycle pulse synthesis is realized by coherently combining near-infrared ($\lambda_0 \sim 0.8\mu$m, $\sim$ 6 fs, $\sim 150\mu$J) and infrared ($\lambda_0 \sim 1.6\mu$m, $\sim$ 8 fs, $\sim 500\ \mu$J) pulses which, after varying their carrier envelope and relative phases, lead to the direct generation of spectrally controlled isolated attosecond pulses (IAPs). Attosecond-resolved measurements characterize the temporal profile of the generated IAPs. Experimental observations are also combined with HHG simulations. Our study will aid research on optimal driver fields for efficient and tunable HHG.

A 2.2 Mon 14:30 A-H1

Reconstruction of Tunnel Ionization Dynamics in Dielectrics from Injection Harmonics
— Peter Jürgens[1], •Benjamin Liewehr[2], Björn Kruse[2], Christian Peltz[2], Tobias Witting[1], Anton Husakou[1], Arnaud Rouzeé[1], Mikhail Ivanov[1], Thomas Fennel[1,2], Mark J. J. Vrakking[1], and Alexandre Mermillod-Blondin[1] — [1]Max-Born-Institute for Nonlinear Optics and Short Pulse Spectroscopy, Berlin, Germany — [2]Institute for Physics, University of Rostock, Germany

The nonlinear response of dielectric solids to strong fields enables high-harmonic generation that has been studied extensively in the context of light-driven intraband charge dynamics and interband recombination [1,2]. However, it was shown recently that these mechanisms do not explain the emission of low harmonic orders which are instead dominated by the strong field tunneling excitation that drives Brunel and injection currents [3]. Based on an ionization-radiation model, we examine signatures and scaling behavior of ionization induced harmonics to reveal the strong-field-induced nonlinearity in time-resolved, low-order wave-mixing experiments in amorphous SiO_2. From the identified injection signal, the tunnel-ionization trace is reconstructed [4], which opens routes for improved control in femtosecond laser processing of solids.

[1] T. T. Luu, et al. Nature **521**, 498 (2015)
[2] G. Vampa, et al. Nature **522**, 462 (2015)
[3] P. Jürgens, B. Liewehr, B. Kruse, et al. Nat. Phys. **16**, 1035 (2020)
[4] P. Jürgens, et al. (accepted) arXiv:2108.03053 (2021)

A 2.3 Mon 14:45 A-H1

Electron dynamical mechanisms for high-harmonic generation in Fibonacci quasicrystals
— •Francisco Navarrete and Dieter Bauer — Institut für Physik-Universität Rostock

The mechanism of high-harmonic generation (HHG) in solids has been theoretically studied over the last two decades, and experimentally verified a decade ago [1]. While many conclusions have been drawn for this process in periodic crystals, it has also been predicted a strong dependence of the HHG spectrum on the topology of the sample [2]. Recently, by the study of a Fibonacci chain, it has been demonstrated that quasicrystals might constitute excellent materials for HHG due to their higher yield [3], when compared with crystals of the same composition. In this presentation, we will discuss the electron-dynamics responsible for HHG in Fibonacci quasicrystals when compared to both crystals and amorphous materials. We will describe the crystal-momentum resolved [4] contributions as well as mechanisms that might explain the yield enhancement as well as the parity of the harmonics in each material.

[1] Shambhu Ghimire *et al*, *Nat. Phys.* **7**, 138(2011)
[2]Christoph Jürß and Dieter Bauer, *Phys. Rev. B* **99**, 195428 (2019)
[3]Jia-Qi Liu and Xue-Bin Bian, *Phys. Rev. Lett.* **127**, 213901 (2021)
[4]Francisco Navarrete, Marcelo F. Ciappina and Uwe Thumm, *Phys. Rev. A* **100**, 033405(2019)

A 2.4 Mon 15:00 A-H1

Making non-adiabatic photoionization adiabatic
— •Jonathan Dubois, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

We consider the process of tunnel ionization of atoms driven by circularly polarized (CP) pulses. An intuitive semiclassical picture of tunnel ionization by a static laser field is an electron ionizing through the potential barrier induced by the laser field with constant energy, referred to as the adiabatic ionization. When the laser field alternates in time, such as it is the case for CP pulses, the energy of the electron changes in time, and at the tunnel exit, it is distributed in a range of energy on the order of the ponderomotive energy of the laser. The adiabatic picture no longer holds, and the ionization process is referred to as nonadiabatic. Extensive theoretical and experimental studies are performed in the attosecond community to probe and understand these nonadiabatic effects in photoionization.

Our goal is to understand nonadiabatic processes in CP pulses using electron trajectories in the combined laser and Coulomb fields. We map the electron dynamics in a frame which rotates with the laser field, referred to as the rotating frame (RF). Our results show that in the RF, counter-intuitively, the energy of the electron is constant during tunnel ionization, and as a consequence follows the picture of adiabatic ionization. This allows us to understand and predict, for instance, the role played by ring currents in atoms and the shape of the laser envelope, and to shed light on classical-quantum correspondence.