A 3: Attosecond physics / Interaction with VUV and X-ray light

Time: Tuesday 10:45–12:45 Location: H1

Invited Talk A 3.1 Tue 10:45 H1

Probing electronic wavefunctions and chiral structure using all-optical attosecond interferometry — •Michael Krüger[1,2], Doron Azoury[1], Omer Kneller[1], Shaked Rozen[1], Barry D. Bruner[1], Alex Clergerie[3], Bernard Pons[3], Baptiste Fabre[3], Yann Mairesse[3], Oren Cohen[2], Olga Smirnova[4], and Nirit Dudovich[1] — [1]Department of Physics of Complex Systems, Weizmann Institute of Science, 76100 Rehovot, Israel — [2]Department of Physics and Solid State Institute, Technion, 32000 Haifa, Israel — [3]Université de Bordeaux, CNRS - CEA, CELIA, Talence, France — [4]Max-Born-Institut, 12489 Berlin, Germany

Phase retrieval of electronic wavefunctions generated by photoionization has been a longstanding challenge. Here we measure the time-reversed process of photoionization – photorecombination – in attosecond pulse generation. We demonstrate all-optical interferometry of two independent phase-locked attosecond light sources [1]. Our measurement enables us to directly determine the phase shift associated with electron scattering and with structural minima in atomic systems.

In a second study, we superimpose two attosecond light sources with perpendicular polarization, achieving direct time-domain polarization control [2]. We establish an extreme-ultraviolet lock-in detection scheme, allowing the isolation and amplification of weak chiral signals. We demonstrate our scheme by a phase-resolved measurement of magnetic circular dichroism.

[1] D. Azoury et al., Nature Photonics 13, 54 (2019).
[2] D. Azoury et al., Nature Photonics 13, 198 (2019).

Invited Talk A 3.2 Tue 11:15 H1

Highly nonlinear ionization of atoms induced by intense HHG pulses — Björn Senfftleben[1], Martin Kretschmar[1], Andreas Hoffmann[1], Mario Sauppe[1,2], Johannes Tümmler[1], Ingo Will[1], Tamás Nagy[1], Marc J. J. Vrakking[1], Daniela Rupp[1,2], and •Bernd Schütte[1] — [1]Max-Born-Institut Berlin — [2]ETH Zürich

High-harmonic generation (HHG) is typically considered to be a weak source of extreme-ultraviolet (XUV) photons. Here we demonstrate a very intense source of few-femtosecond XUV pulses based on HHG, reaching intensities up to 7×10^{14} W/cm^2 [1]. These pulses enable us to ionize Ar atoms up to Ar^{5+}, requiring the absorption of at least 10 XUV photons. This number can be appreciated by considering that it is similar to the number of near-infrared (NIR) photons absorbed in a typical strong-field ionization experiment.

Our results are the consequence of a novel scaling scheme, showing that the optimization of the XUV intensity requires conditions that are distinctly different from the conditions that are required to optimize the HHG pulse energy. An important advantage of our approach is that we use a moderate NIR pulse driving energy ($\approx$ 10 mJ). Therefore, our results make it possible to perform experiments requiring intense XUV pulses in a much larger number of laboratories than is currently the case. This substantially improves the prospects for nonlinear XUV optics experiments, single-shot coherent diffractive imaging of isolated nanotargets as well as attosecond-pump attosecond-probe experiments.

[1] B. Senfftleben *et al.*, arXiv:1911.01375

Invited Talk A 3.3 Tue 11:45 H1

Towards fast adaptive resonant x-ray optics — Miriam Gerharz and •Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Visible light can easily be manipulated using reflective or refractive elements, such as lenses, phase plates, or mirrors. At x-ray energies, the real part of the complex refractive index approaches 1, such that these concepts require revision. As a result, an impressive toolbox of alternative methods has been developed, e.g., based on crystal optics.

In this talk, I will introduce a new concept for fast adaptive x-ray optics, which in particular aims at dynamical control during single experimental cycles. Our approach uses piezo-control methods, which allow one to mechanically displace a solid-state target containing resonances much faster than the lifetime of the resonances. Such displacements create relative phase shifts, which already have been employed successfully to manipulate the time- or energy spectra of x-ray pulses.

For applications in x-ray optics, we associate the phase shifts to an effective real part of the refractive index. The key idea then is that such mechanically-induced phase shifts are independent of the thickness of the target. As a result, the real part of the x-ray refractive index can effectively be increased substantially, without increasing its imaginary part. This approach provides access to high refractive index contrasts at x-ray energies together with low absorption, and thereby opens an avenue to entirely new concepts in x-ray optics.

Invited Talk A 3.4 Tue 12:15 H1

Control of complex Fano resonances by shaped laser pulses — Camilo Granados, Nicola Mayer, Evgenii Ikonnikov, Misha Ivanov, and •Oleg Kornilov — Max-Born-Institute, Berlin

Ultrafast pulsed lasers and high-order harmonic generation have opened access to time-dependent studies in the extreme ultriviolet (XUV) photon energy range. Excited states accessible in the XUV region often have a complex character combining several coupled electronic states, such as multi-state Fano resonances, and undergo ultrafast relaxation dynamics via autoionization, dissociation or relaxation at conical intersections. Recently we investigated dynamics of the complex excited molecular states using time-resolved photoelectron [1,2] and photoion [3] spectroscopy with wavelength-selected XUV pulses. In this contribution we explore how these dynamics can be controlled by temporal and frequency shaping of the near-infrared pulses used to probe the relaxation dynamics induce by XUV.

[1] M. Eckstein et al., Phys. Rev. Lett. 116, 163003 (2016). [2] M. Eckstein et al., Faraday Discuss. 194, 509 (2016). [3] G. Reitsma et al., J. Phys. Chem. A 123, 3068 (2019).