A 26: Interaction with VUV and X-ray light II

Time: Thursday 14:00–16:00 Location: f107

Invited Talk A 26.1 Thu 14:00 f107

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 26.2 Thu 14:30 f107

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).

A 26.3 Thu 15:00 f107

Tracking Attosecond Electronic Coherences Using Phase-Manipulated Extreme Ultraviolet Pulses — •Andreas Wituschek, Lukas Bruder, and Frank Stienkemeier — Institute of Physics, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany

Coherent control and nonlinear spectroscopy schemes are powerful tools that allow the study and control of the dynamics of quantum systems. Novel light sources in the extreme ultraviolet (XUV) region paved the way for the extension of these tools to the XUV, allowing experiments with an unprecedented temporal resolution and site selectivity. However, this promise has not yet been met due to the experimental challenges arising at these short wavelengths.

In this work we use an XUV pulse pair created at the FERMI free-electron laser to measure directly in the time domain the coherent evolution and dephasing of electronic XUV wave packets. Independent control over relative phase and delay of the pulse pair allowed us to introduce a phase-cycling scheme, readily used in the visible regime. This provided the necessary interferometric stability and sensitivity to track the ultrafast coherences (150 as). Our technique facilitates a wide range of nonlinear spectroscopy as well as coherent control schemes, and is universally applicable to the whole wavelength range accessible with seeded FELs. In addition, it can be combined with tabletop High Harmonic Generation sources. Additional information and a complete list of collaborateurs of this project can be found here: A. Wituschek et al., arXiv:1906.07112 (2019)

A 26.4 Thu 15:15 f107

Spectral Compression of XUV Radiation by Four-Wave-Mixing — •Lorenz Drescher, Vishal Shokeen, Tobias Witting, Oleg Kornilov, Marc Vrakking, and Bernd Schütte — Max-Born-Institut für nichtlineare Optik und Kurzzeitspektroskopie, Berlin, Germany

We present and demonstrate a novel concept for the efficient generation of narrowband extreme ultra-violet (XUV) radiation that is based on the conversion of broadband attosecond pulse trains and few-cycle NIR pulses via a four-wave mixing process. Spectral compression of broadband XUV radiation is achieved by exploiting the steep gradient of the frequency-dependent refractive index between two closely spaced resonances, while the nearly flat dispersion in the incident vacuum ultraviolet (VUV) and XUV regimes allows for broadband phase-matching. We demonstrate the concept by propagating XUV pulses created by high-harmonic generation through a dense krypton gas jet and observe a narrow emission peak in between the Kr 4d and 6s resonances. The non-resonant nature and generality of the reported process offers new opportunities for tailoring the spectral bandwidth of XUV beams.

A 26.5 Thu 15:30 f107

Dispersive soft x-ray absorption fine-structure spectroscopy in graphite with an attosecond pulse — •Themistoklis P. H. Sidiropoulos[1], Bárbara Buades[1], Dooshaye Moonshiram[2], Iker León[1], Peter Schmidt[1], Irina Pi[1], Nicola Di Palo[1], Seth L. Cousin[1], Antonio Picón[1], Frank Koppens[1,3], and Jens Biegert[1,3] — [1]ICFO-Institut de Ciencies Fotoniques, 08860 Castelldefels, Spain — [2]Institute of Chemical Research of Catalonia, 43007 Tarragona, Spain — [3]ICREA, 08010 Barcelona, Spain

X-ray absorption fine-structure (XAFS) spectroscopy is a powerful element-specific technique, providing electronic and structural information with atomic resolution. Electronic information is extracted from the near-edge XAFS (NEXAFS) spectrum, requiring high spectral resolution to resolve features that occur within a few eV near the absorption edge. Structural information is obtained from the extended XAFS (EXAFS), spreading over several hundred eV above the absorption edge. While XANES and EXAFS are both well-established methods, crucially lacking so far is the capability to connect electronic with structural information in real-time. Here, we present a decisive step towards such new methodology based on water-window-covering (280 eV to 540 eV) attosecond soft X-ray pulses that can simultaneously access electronic and lattice parameters via dispersive XAFS spectroscopy. We validate this approach with an identification of the orbital contributions to the density of states in graphite simultaneously with the four characteristic bonding distances. This work demonstrates the potential of dispersive attosecond XAFS as a powerful spectroscopic tool.

A 26.6 Thu 15:45 f107

An XUV frequency comb for precision spectroscopy of trapped highly charged ions — •Jan-Hendrik Oelmann, Janko Nauta, Alexander Ackermann, Patrick Knauer, Ronja Pappenberger, Nick Lackmann, Steffen Kühn, Julian Stark, Thomas Pfeifer, and José R. Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

In order to perform spectroscopy of highly charged ions in the extreme ultraviolet (XUV) with unprecedented resolution, we have built an XUV frequency comb by transferring a near-infrared frequency comb to the XUV by means of high-harmonic generation [1,2]. To reach the required peak intensity levels at a 100 MHz repetition rate, 200 fs laser pulses are amplified to 80 W in a chirped-pulse fiber amplifier and resonantly overlapped in a femtosecond enhancement cavity [3]. By this means, an average power of 25 kW, corresponding to a peak intensity of $\approx 3 \cdot 10^{14}\,\mathrm{W/cm^2}$, is reached in the cavity focus. High harmonics up to the 35^{th} order are coupled out of the cavity and will be guided to trapped and sympathetically cooled highly charged ions [4] in a superconducting Paul trap to perform direct XUV frequency comb spectroscopy.

[1] C. Gohle et al., Nature 436, 234-237 (2005).
[2] G. Porat et al., Nat. Photon, 12, 387 - 391 (2018).
[3] J. Nauta et al., Nucl. Instrum. Meth. B 408, 285 (2017).
[4] L. Schmöger et al., Science 347, 1233 (2015).