K 1: Optical Methods - EUV and x-ray Sources

Time: Monday 14:00–15:55 Location: MB HS

Invited Talk K 1.1 Mon 14:00 MB HS

Abklingzeit, Zufall und Information — •Rudolf Germer — ITPeV, Berlin — TU-Berlin

Welche Rolle spielt Informationen als physikalische Größe? Um einer Antwort auf diese Frage näher zu kommen, wollen wir uns im folgenden Beitrag mit der Abklingzeit fluoreszierender Atome beschäftigen. Solche Fluoreszenz ist ohne Zweifel vom Zufall begleitet, wir können nicht vorhersagen, welches Atom von den angeregten zu welcher Zeit seine Energie abgibt, nur das Verhalten von vielen Atomen kann global beschrieben werden. Parallel dazu können wir das Entladen von einem großen oder vielen kleinen Kondensatoren betrachten und im Vergleich feststellen, auf welche Art Energie und Information zusammengehören. Ergänzt mit Würfelexperimenten kann man schließlich sehen, an welcher Stelle Naturgesetze ihre Wirkung zeigen und wie der Zufall eine Brücke zwischen der klassischen und der Quantenbeschreibung liefert.

K 1.2 Mon 14:40 MB HS

Narrow-band hard-x-ray lasing — •Chunhai Lyu, Stefano M. Cavaletto, Zoltán Harman, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

We put forward a scheme to obtain a narrow-band x-ray laser by K-shell photoionization of Li-like highly charged ions in a laser-generated plasma. Ions of Ne, Ar, Kr and Xe have been examined. Numerical simulations show that the intensities of such x-ray lasers saturate within a few millimeters with transform-limited profiles. Such temporal coherences provide x-ray laser bandwidths up to three orders of magnitude narrower compared to the future seeded-XFEL sources in the hard x-ray regime.

K 1.3 Mon 14:55 MB HS

Ptychographic Wavefront Measurement of a High Harmonic Seeded Soft X-ray Laser — •Michael Zürch[1,2,3], Frederik Tuitje[1], Tobias Helk[1], Julian Gautier[4], Fabian Tissandier[4], Jean Philippe Goddet[4], Stephane Sebban[4], and Christian Spielmann[1,2] — [1]Institute of Optics and Quantum Electronics, Abbe Center of Photonics, Jena University, Jena, Germany — [2]Helmholtz Institute Jena, Jena, Germany — [3]Department of Chemistry, University of California, Berkeley, CA 94720, USA — [4]LOA, ENSTA, CNRS, Ecole Polytechnique, Universite Paris-Saclay, F-91762 Palaiseau cedex, France

Soft X-ray lasers (SXRL) are intense sources of quasi-monochromatic coherent short wavelength radiation with pulse durations of about 1 ps in a table top scheme. The beam quality of a SXRL can be significantly enhanced by seeding the X-ray amplifier with a laser-driven high harmonic generation (HHG) source. Here, we employ ptychographic coherent diffraction imaging for nanoscale imaging as well as measuring the complex-valued illumination function of a HHG-seeded SXRL operating at 32.8 nm wavelength with high fidelity. Backpropagation of the field allows determining source properties in unprecedented quality. We find that HHG seeding results in excellent spatial coherence properties, while a high degree of temporal coherence is maintained through the narrow-band amplification. The results suggest that HHG-seeded SXRL are combining high photon flux ($>10^{12}$ photons/shot) with excellent spatial and temporal coherence properties rendering it an ideal source for high resolution coherent X-ray imaging.

K 1.4 Mon 15:10 MB HS

Continuously wavelength-tunable high harmonics generation via soliton dynamics — •Francesco Tani[1], Michael H. Frosz[1], John J.C. Travers[1,2], and Philip St.J. Russell[1] — [1]Max Planck Institute for the Science of Light, Staudtstr. 2, 91058 Erlangen, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, EH14 4AS, UK

Soliton dynamics offer a range of powerful tools for nonlinear manipulation of ultrashort light pulses. In gas-filled hollow-core photonic crystal fiber (HC-PCF), the weak anomalous dispersion supports solitons over a broad spectral range in the visible and infrared regions. By exploiting these dynamics, gas-filled HC-PCFs have been successfully used, within a broad range of laser wavelengths, for pulse self-compression down to single cycle durations and for upshifting the pulse central frequency. Here we combine a gas-filled HC-PCF with a gas-jet for high harmonic generation (HHG), driven by laser pulses of a few tens of micro-Joule, which undergo soliton self-compression in the fiber. We show that by exploiting the interaction of the soliton with free electrons created by ionization in the gas, we can continuously upshift the soliton frequency and as a result tune the frequency of the generated harmonics. In this way, we achieved a blue-shift of almost 3 eV, while keeping the ionization in the gas jet at a low level (high levels degrade the coherence of the harmonics). The high efficiency and low pulse energies suggest that this HHG scheme will open a new route to developing a tunable extreme ultraviolet sources that, uniquely, can easily be scaled to MHz repetition rates.

K 1.5 Mon 15:25 MB HS

Nanoscale magnetic imaging using high-harmonic radiation in the extreme-UV — •Ofer Kfir[1,2], Sergey Zayko[1], Christina Nolte[1], Murat Sivis[1], Marcel Möller[1], Birgit Hebler[3], Sri Sai Phani Arekapudi[3], Daniel Steil[1], Sascha Schäfer[1], Manfred Albrecht[3], Oren Cohen[2], Stefan Mathias[1], and Claus Ropers[1] — [1]University of Göttingen, Göttingen, Germany — [2]Technion, Haifa, Israel — [3]University of Augsburg, Augsburg, Germany

Pulsed extreme-UV (EUV) and X-ray beams offer a unique probe for element specific imaging of magnetic textures and their dynamics [1-3]. To date, such experimentas are available exclusively at synchrotrons and free-electron lasers, producing a high flux of coherent short-wavelength radiation with circular polarization.

Here, we demonstrate nanoscale magnetic imaging using high harmonic radiation. By controlling the circular polarization of the EUV beam [4], we harness resonant XMCD contrast of cobalt in a Co/Pd multilayer stack. We enhance the scattering signal by a strong auxiliary wave, comprised of multiple spatial waveguide modes [5]. The reconstructed image shows sub 50-nm spatial resolution. These results open the path towards an element-specific probing of magnetic dynamics at the nanometer- and femtosecond-scales, in a setup as compact as an optical table.

[1] Eisebitt, Nature, 432, 885 (2004) [2] Willems, Struct. Dynam. 4, 014301 (2017) [3] Büttner, Nat. Phys. 11 255 (2015) [4] Kfir, APL 108 211106 (2016) [5] Zayko, Opt. Exp. 23, 19911 (2015)

K 1.6 Mon 15:40 MB HS

Generation of microjoule pulses in the deep ultraviolet at megahertz repetition rates — •Felix Köttig[1], Francesco Tani[1], Christian Martens Biersach[1], John C. Travers[1,2], and Philip St.J. Russell[1] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, UK

Although ultraviolet (UV) light is important in many areas of science and technology, there are very few if any sources capable of delivering wavelength-tunable ultrashort UV pulses at high repetition rates. Dispersive wave (DW) emission from self-compressed solitons in gas-filled hollow-core photonic crystal fiber (PCF) provides a powerful approach, offering simple wavelength-tunability, low requirements on the pump energy and high conversion efficiency. We report the generation of deep UV pulses at megahertz repetition rates and microjoule energies by means of DW emission in gas-filled single-ring hollow-core PCF. Pulses from an ytterbium fiber laser (~300 fs) are first compressed to <25 fs in a single-ring PCF-based nonlinear compression stage and subsequently used to pump a second single-ring PCF stage for broadband DW generation in the deep UV. The UV wavelength is tunable by selecting the gas species and the pressure. Through rigorous optimization of the system, in particular employing a large-core fiber filled with light noble gases, we achieve 1 μJ pulse energies in the deep UV, which is more than 10 times higher, at average powers more than four orders of magnitude greater (reaching 1 W) than previously demonstrated, with only 20 μJ pulses from the pump laser.