A 27: XUV/X-ray Science

Time: Wednesday 14:00–16:15 Location: K 1.011

A 27.1 Wed 14:00 K 1.011

XUV-Pump/XUV-Probe Strong-field Transient Absorption of Neon at FLASH — •Thomas Ding[1], Marc Rebholz[1], Lennart Aufleger[1], Maximilian Hartmann[1], Kristina Meyer[1], Alexander Magunia[1], David Wachs[1], Veit Stooss[1], Paul Birk[1], Gergana Borisova[1], Andrew Attar[2], Thomas Gaumnitz[3], Zhi Heng Loh[4], Sebastian Roling[5], Marco Butz[5], Helmut Zacharias[5], Stefan Düsterer[6], Rolf Treusch[6], Stefano Cavaletto[1], Zoltán Harman[1], Christian Ott[1], and Thomas Pfeifer[1] — [1]Max-Planck Institut für Kernphysik, Heidelberg, Germany — [2]University of California Berkeley, Berkeley, USA — [3]Eidgenössische Technische Hochschule Zürich, Zürich, Switzerland — [4]Nanyang Technological University Singapore, Singapore — [5]Westfälische Wilhelms-Universität Münster, Münster, Germany — [6]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

We present first transient-absorption spectroscopy experiments with extreme ultraviolet (XUV) pump and probe pulses delivered by the free-electron laser FLASH. Applying our pump-probe scheme at photon energies around 50 eV, pulse durations of about 50 fs and intensities up to 10^{14} Wcm^{-2} to neon, we traced the sequential two-photon ionization plus the excitation of one-photon bound-bound transitions within the doubly charged Ne^{2+} ion. Analyzing the nonlinear absorption spectra as a function of the pulse delay and the intensity reveals resonant XUV strong-field coupling of those transitions and allows to retrieve the FLASH coherence time from transient absorption spectra.

A 27.2 Wed 14:15 K 1.011

Angle-resolved observation of X-ray second harmonic generation in diamond — •Björn Senfftleben[1], Priyanka Chakraborti[1], Brendan Kettle[1,2], Dilling Zhu[3], Takahiro Sato[3], Silke Nelson[3], Samuel Teitelbaum[4], Phillip H. Bucksbaum[4], Jerome B. Hastings[4], Sharon Shwartz[5], David A. Reis[4], and Matthias Fuchs[1,4] — [1]University of Nebraska-Lincoln, Lincoln, NE, USA — [2]Imperial College, London, UK — [3]Linac Coherent Light Source, Menlo Park, CA, USA — [4]Stanford Pulse Institute, Menlo Park, CA, USA — [5]Bar-Ilan University, Ramat Gan, Israel

For a long time, the limited X-ray intensity of classical light sources have restricted experimental investigations of non-linear effects in the X-ray regime. With the advent of X-ray free-electron lasers (XFELs), it has become possible to explore new parameter spaces and to study X-ray matter interactions in the nonlinear regime. First experiments have tested the limits of current theoretical models.

Here we report the observation of angularly-resolved X-ray second harmonic generation (XSHG) in diamond at several phase-matching geometries. The quadratic dependence of the number of generated second harmonic photons on the incident pulse energy was verified. Further, the angular dependence of the efficiency and the rocking curve widths of the process were investigated. A good agreement with the theory has been found.

A 27.3 Wed 14:30 K 1.011

Measuring sub-Ångström translations by time-domain interferometry — •Stephan Goerttler[1], Andreas Kaldun[1], Christian Ott[1], Kilian Heeg[1], Patrick Reiser[1], Cornelius Strohm[2], Johann Haber[2], Rajagopalan Subramanian[1], Rudolf Rüffer[3], Ralf Röhlsberger[2], Jörg Evers[1], and Thomas Pfeifer[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany — [3]ESRF-European Synchrotron, CS40220, 38043 Grenoble Cedex 9, France

The temporal phase of a coherently emitted pulse is inextricably linked to the translation of the emitter in space. We use interferometry in the time domain and a direct analytical phase-reconstruction algorithm to retrieve the temporal phase imprinted onto the 14.4-keV emission line of ^{57}Fe. As the wavelength of this transition is very small ($\lambda = 0.82$Å) we can determine the motion of the emitter on sub-Ångström length and nanosecond time scale.

A 27.4 Wed 14:45 K 1.011

Controlling Excitation Dynamics of Mössbauer Nuclei — •Kilian P. Heeg[1], Andreas Kaldun[1], Cornelius Strohm[2], Patrick Reiser[1], Christian Ott[1], Rajagopalan Subramanian[1], Dominik Lentrodt[1], Johann Haber[2], Hans-Christian Wille[2], Stephan Goerttler[1], Rudolf Rüffer[3], Christoph H. Keitel[1], Ralf Röhlsberger[2], Thomas Pfeifer[1], and Jörg Evers[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [3]ESRF - The European Synchrotron, Grenoble, France

Mössbauer nuclei with transitions in the hard x-ray regime are usually probed by single x-ray pulses only, such that advanced concepts in light-matter interaction which, e.g., require control fields, cannot be realized straightforwardly. Here, we generalize a recent method to spectrally amplify x-ray pulses [1] to generate a sequence of two pulses with controlled relative phase. Such tailored x-rays are employed in a two-step interaction scheme: preparation and subsequent control of the excitation dynamics in a resonant target of ^{57}Fe Mössbauer nuclei. Our experimental results confirm that the collective nuclear dipole response can indeed be manipulated and we find clear signatures of fundamental processes in light-matter interaction such as stimulated emission and absorption.

[1] K. P. Heeg *et al.*, Science 357, 375 (2017).

A 27.5 Wed 15:00 K 1.011

Rabi oscillations of x-ray radiation between two nuclear ensembles — Xiangjin Kong[1], Johann Haber[2], Ralf Röhlsberger[2], and •Adriana Pálffy[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Deutsches Elektronen-Synchrotron DESY, Hamburg

The realization of the strong coupling regime between a single cavity mode and an electromagnetic resonance is one of the centerpieces of quantum optics. In this regime, the reversible exchange of a photon between the two components of the system leads to so-called Rabi oscillations [1]. Strong coupling was used in the optical and infrared regimes to produce non-classical states of light, enhance optical nonlinearities, and control quantum states for computing purposes.

Here, we report from the theory side on the first observation of Rabi oscillations of an x-ray photon between two resonant ^{57}Fe-layers embedded in two coupled cavities [2]. The theoretical predictions for the observed oscillation are based on an effective Hamiltonian for the system, in which the two layers couple strongly. A sinusoidal beating in the system's temporal evolution as signature of the Rabi oscillations, as well as the splitting of the nuclear resonances in the reflected light spectrum have been confirmed by experiment. These observations significantly advance the development of the new field of x-ray quantum optics.

[1] M. Brune *et al.*, Phys. Rev. Lett. 76, 1800 (1996).
[2] J. Haber *et al.*, Nature Photonics 11, 720 (2017).

A 27.6 Wed 15:15 K 1.011

Ion-source Development for Inner-Shell Photodetachment of Negative Ions — •Alexander Perry-Sassmannshausen[1], Paul Willamowski[1], Ticia Buhr[1], Alfred Müller[2], and Stefan Schippers[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen — [2]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen

A research plan has been devised for studying inner-shell photoionization of negative atomic ions at the PIPE end station of beam line P04 of PETRA III at DESY in Hamburg. First results have already been obtained for double and triple photodetachment of O^- [1] and F^- [2] ions resulting from K-shell ionization or excitation. In the future, also heavier ions will be investigated. To this end, a new Cs-sputter ion source is currently commissioned in Giessen. Results from performance tests of the new ion source will be presented.

[1] S. Schippers *et al.*, Phys. Rev. A **94**, 041401(R) (2016).
[2] A. Müller *et al.*, (submitted).

A 27.7 Wed 15:30 K 1.011

Auger cascade calculations for astrophysically relevant ions — •Randolf Beerwerth[1,2], Sebastian Stock[1,2], Stefan Schippers[3], and Stephan Fritzsche[1,2] — [1]Helmholtz Institut Jena, 07743 Jena — [2]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, 07743 Jena — [3]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Giessen

We performed Auger cascade calculations to model the deexcitation pathways that follow upon direct ionization or resonant excitation of inner shell electrons. By building the complete deexcitation trees, we can compute cross sections and ion yields that are useful for e.g. plasma modeling in astrophysical applications. Of special importance for these applications are several isotopes of iron, which are the target of experimental campaigns with the photon-ion merged-beams setup PIPE [1]. We present our calculations for the multiple ionization of Fe^{1+} and Fe^{3+}, where experimental data is available [1, 2] as well as for Fe^{2+}, where an experimental campaign is planned.

Previous configuration average calculations are not in good agreement with the experimental results, which is resolved by our model at fine structure level. For higher charge states, several three electron Auger processes become crucial where an additional shake down transition provides a sufficient gain in energy for an additional Auger decay. Including such transitions drastically modifies the computed ion yields and leads to a good agreement with experimental results.

[1] S. Schippers et al., Astrophys. J. 849 (2017) 5.
[2] R. Beerwerth et al., submitted

A 27.8 Wed 15:45 K 1.011

Comprehensive study of nondipole effects in photoionization of the He 1*s* and Ne 2*s* shells — •Ticia Buhr[1], Levente Abrok[2], Akos Köver[2], Beatrix Pollakowski-Herrmann[3], Jan Weser[3], Jan Dreismann[1], David Nagy[2], Daniel Paul[1], Dezso Varga[2], Alfred Müller[1], Burkhard Beckhoff[3], Stefan Schippers[1], and Sandor Ricz[2] — [1]Justus-Liebig-Universität Gießen, Gießen — [2]Institute for Nuclear Research, Hungarian Academy of Sciences, Debrecen, Hungary — [3]Physikalisch-Technische Bundesanstalt, Berlin

Nondipole effects strongly modify the polar and azimuth angle dependence of the double differential cross section of the photoelectron emission [1]. In order to study these effects in detail, angular distributions of He 1*s* and Ne 2*s* photoelectrons were measured over wide ranges of the polar and azimuth angles covering a solid angle of about 2π. The experiments were carried out at the beam line PTB-XRS of BESSY II using linearly polarized photons. The photoelectrons were detected with an ESA-22-type electrostatic electron spectrometer [2] in in-plane as well as in off-plane geometry determined by the photon momentum and polarization vectors. The observed disagreement between the experimental and theoretical angular distributions might be explained with the neglected terms in the calculations [1].

[1] A. Derevianko *et al.*, At. Data Nucl. Data Tables **73**, 153 (1999).
[2] L. Ábrók *et al.*, Nucl. Instrum. Methods B **369**, 24 (2016).

A 27.9 Wed 16:00 K 1.011

Rayleigh scattering of twisted light by hydrogenlike ions — •Anton Peshkov[1], Andrey Volotka[1], Andrey Surzhykov[2,3], and Stephan Fritzsche[1,4] — [1]Helmholtz-Institut Jena, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Technische Universität Braunschweig, Germany — [4]Friedrich-Schiller-Universität Jena, Germany

The elastic scattering of photons by bound electrons of atoms, commonly known as Rayleigh scattering, has attracted much interest in experiment and theory as one of the simplest second-order quantum electrodynamical process. In particular, the measurement of the linear polarization of the elastically scattered plane-wave radiation has been recently performed at the PETRA III synchrotron at DESY [1]. Until the present, however, very little is known about the scattering of twisted light. When compared to plane-wave photons, such twisted photons carry a well-defined projection of the orbital angular momentum [2]. Here we analyze theoretically the behavior of the polarization Stokes parameters of scattered photons for the elastic scattering of twisted Bessel light by means of the Dirac's relativistic equation. Special attention was paid to the scattering on three different atomic targets: a single atom, a mesoscopic (atoms in a trap) and a macroscopic (foil) targets. Our calculations indicate that the Stokes parameters of the scattered twisted light may significantly differ from their behaviour for an incident plane-wave radiation.

[1] K.-H. Blumenhagen *et al.*, New J. Phys. 18, 103034 (2016).
[2] A. A. Peshkov *et al.*, Phys. Rev. A 96, 023407 (2017).