A 8: XUV/X-ray spectroscopy II

Time: Monday 17:00–19:00 Location: N 2

Invited Talk A 8.1 Mon 17:00 N 2

Angular resolved inner-shell photoionization spectra of randomly oriented and fixed-in-space methane and methyloxirane — •Philipp Demekhin — Institut für Physik und CINSaT, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel

Recent progress in the development of experimental detection techniques enabled a set of new experiments on molecular photoionization in the angular-resolved mode. Interpretation of the results of such experiments requires development of new advanced nonstandard theoretical and computational approaches. In this talk, we first discuss theoretical background of the angular-resolved spectroscopy of molecules, and then consider two recent applications performed by the theoretical methods developed in our group. For core-to-Rydberg excited methane [1], we demonstrate that angular-resolved resonant Auger decay spectra provide very insightful information on the strength of the vibronic coupling effects. For O(1s) ionization of methyloxirane [2], we show that chiral asymmetry (photoelectron circular dichroism) can be significantly enhanced already by fixing one molecular orientation axis.

[1] A. Knie, et al., Phys. Rev. Lett. **116**, 193002 (2016).
[2] M. Tia, et al., arXiv:1609.03828v1 (2016).

Invited Talk A 8.2 Mon 17:30 N 2

Circular Dichroism in Multi-Photon Ionization of Oriented Helium Ions — •Markus Ilchen[1], Nicolas Douguet[2], Tommaso Mazza[1], Klaus Bartschat[2], Alexei Grum-Grzhimailo[3], Nikolay Kabachnik[3], and Michael Meyer[1] — [1]European XFEL GmbH, Schenefeld, Germany — [2]Drake University, Des Moins, USA — [3]Lomonosow Moscow State University, Moscow, Russia

The dichroic interaction of circularly polarized X-rays with matter is a multi-disciplinary field of science. With the advent of circularly polarized free-electron laser (FEL) radiation [1,2], the research field of circular dichroism phenomena in non-linear and ultrafast physics has been extended to the soft X-ray regime. Using high intensity, narrow bandwidth XUV pulses from FERMI in Italy, we were able to resonantly orient ionic helium in the 3p (m=+1) magnetic sub-state and to control the population of this state by a helicity dependent AC Stark shift generated by an overlapped near-infrared laser. The measured circular dichroism of electrons emitted via multi-photon ionization of the 3p state is intensity dependent to a surprisingly strong extent, therefore, allowing for an easily controllable and polarization selective transparency of such resonances. Potential applications in the general context of chirality research at FELs will be discussed. [1] E. Allaria et al., Phys. Rev. X, 4, 041040 (2014) [2] A. A. Lutman et al., Nature Photon., 10, 468 (2016)

A 8.3 Mon 18:00 N 2

X-ray laser spectroscopy with few-electron highly charged ions — •Sven Bernitt[1,2] and José R. Crespo López-Urrutia[2] — [1]IOQ, Friedrich-Schiller-Universität Jena, Germany — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Electronic transitions in few-electron highly charged ions are prominent in a variety of astrophysical and laboratory plasmas, and high precision spectroscopic data is indispensable for the interpretation of their X-ray spectra.

We have used a transportable electron beam ion trap (EBIT) to provide helium- and lithium-like ions of different elements as targets for monochromatized X-rays from synchrotron and free-electron laser light sources. By detecting resonantly excited fluorescence as a function of the photon energy, we were able to perform high precision spectroscopic studies, yielding transition energies, natural line widths and branching ratios.

This also serves as benchmark for the possible use of highly charged ions as future X-ray wavelength standards, and allows us to test current atomic theories, including electron-electron interactions, on the level of QED contributions.

A 8.4 Mon 18:15 N 2

Theoretical investigation of X-ray nonlinear Compton scattering — •Dietrich Krebs[1,2], David A. Reis[3], and Robin Santra[1,2] — [1]Center for Free-Electron Laser Science, DESY, Notkestrasse 85, 22607 Hamburg, Germany — [2]Department of Physics, University of Hamburg, Jungiusstrasse 9, 20355 Hamburg, Germany — [3]Stanford PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, California 94025, USA

Motivated by a recent experiment [1], we theoretically investigate the process of X-ray nonlinear Compton scattering. Our approach is based on the time-dependent Schrödinger equation for an atomic system subject to an intense X-ray pulse and explicitly accounts for the spontaneous scattering into a quantized photonic mode. To the best of our knowledge, this is the first time a time-dependent QED description has been attempted for a realistic system. We validate our implementation by calculating the linear Compton scattering signal for Helium at 500 eV photon energy and verify the dominance of the first-order A^2 mechanism. Subsequently, we explore the processes underlying X-ray nonlinear Compton scattering within the same framework. In contrast to the second-order mechanism that experience with linear Compton scattering would suggest, we find that X-ray two-photon Compton scattering in the soft X-ray regime is dominated by certain third-order processes. Moreover, our calculations demonstrate that the nonlinear Compton spectrum extends to much lower energies than would be expected from analogy with the sharply peaked linear case.

[1] M. Fuchs et al., Nature Physics 11, 964-970 (2015)

A 8.5 Mon 18:30 N 2

Inducing and detecting collective population inversions of Mössbauer nuclei — •Kilian P. Heeg, Christoph H. Keitel, and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Up to now, experiments involving Mössbauer nuclei driven by x-rays have been restricted to the low-excitation regime. In this talk, we propose a setup which promises significant excitation, ideally exceeding full inversion of the nuclear ensemble, at x-ray light sources under construction. We further introduce a method to experimentally verify such inversions, in which population inversions manifest themselves in symmetry flips of suitably recorded spectra. It neither requires per-shot spectra of the incoming x-ray pulses, nor absolute measurements of the scattered light intensity.

K. P. Heeg, C. H. Keitel, J. Evers, arXiv:1607.04116 [quant-ph] (2016).

A 8.6 Mon 18:45 N 2

Sub-envelope dynamics of slow electrons from non-adiabatic transitions — •Qi-Cheng Ning, Ulf Saalmann, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

Ultra-short, intense and high-frequency laser pulses are able to release a bunch of slow electrons from atomic systems as the consequence of non-adiabatic transitions [1-3]. We find the formations of slow electrons peaks possess quite crucial dynamic origins which are intrinsic and have never been recognized. The previous observed peaks [1-3] should be comprehended as coherently combined outcomes of the continuum wavepackets launched by left hand side and right hand side of the laser envelope. The electron energy spectra exhibit oscillatory features and they are attributed to Stückelberg interferences, to achieve a profound understanding of the dynamic processes, we put forward numerical experiments using one single laser pulse which can be regarded as a pump-probe setup to reconstruct the quantum phases differences between wavepackets. As one other aspect of envelope dynamics, continuum-continuum non-adiabatic transitions are found appreciable to reshuffle distributions of electron energy spectra and they function oppositely at two sides of the pulse due to inverse slopes of the laser envelopes.

[1] M. Førre, S. Selstø, J. P. Hansen, and L. B. Madsen, Phys. Rev. Lett. **95**, 043601 (2005). [2] K. Toyota, O. I. Tolstikhin, T. Morishita, and S. Watanabe, Phys. Rev. Lett. **103**, 153003 (2009). [3] K. Toyota, U. Saalmann, and J. M. Rost, New J. Phys. **17**, 073005 (2015).