A 14: Interaction with VUV and X-ray light

Time: Wednesday 10:30–12:15 Location: A-H1

Invited Talk A 14.1 Wed 10:30 A-H1

Synchrotron radiation experiments with highly charged ions — •Jose R. Crespo López-Urrutia[1], Steffen Kühn[1], Moto Togawa[1], Marc Botz[1], Jonas Danisch[1], Joschka Goes[1], René Steinbrügge[2], Sonja Bernitt[1,3], Chintan Shah[1,4], Maurice A. Leutenegger[4], Ming Feng Gu[5], Marianna Safronova[6], Jakob Stierhof[7], Thomas Pfeifer[1], and Jörn Wilms[7] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]DESY, 22607 Hamburg, Germany — [3]Helmholtz-Institut Jena, 07743 Jena, Germany — [4]NASA/Goddard Space Flight Center, Greenbelt, MD 20771, USA — [5]Space Sciences Laboratory, UC Berkeley, CA 94720, USA — [6]Dept. of Physics and Astronomy, University of Delaware, Newark, DE 19716, USA — [7]Dr. Karl Remeis-Observatory, 96049 Bamberg, Germany

Synchrotrons provide intense, highly monochromatic X-rays which we use for exciting highly charged ions (HCI) produced and confined in electron beam ion traps. This gives access to a regime of radiation-matter interaction dominant in hot astrophysical plasmas such as active galactic nuclei, accretion disks, and stellar radiative cores as well as coronae. Unlike neutrals, HCI thrive under those extreme conditions, modifying energy transfer and delivering spectral lines for diagnostics. Space missions need laboratory-tested theory for their science goals. We study X-ray photoexcitation and photoionization of HCI, test the related theory with unprecedented accuracy, solve two longstanding astrophysical questions, and enable future stringent tests of quantum electrodynamic calculations in complex isoelectronic sequences.

A 14.2 Wed 11:00 A-H1

Influence of multiple transitions for Quantum Coherent Diffractive Imaging — •Björn Kruse[1], Benjamin Liewehr[1], Christian Peltz[1], and Thomas Fennel[1,2] — [1]Institute for Physics, University of Rostock, Germany — [2]Max-Born-Institute for Nonlinear Optics and Short Pulse Spectroscopy, Berlin, Germany

Coherent diffractive imaging (CDI) of isolated helium nanodroplets has been successfully demonstrated with a lab-based HHG source [1] operating in the vicinity of the 1s - 2p transition of helium. Near such strong resonances, a non-linear theoretical description including quantum coherence is required. We developed a density matrix-based scattering model in order to include quantum effects in the local medium response and explored the signatures of transition from linear to non-linear CDI for the resonant scattering from Helium nanodroplets [2]. We found substantial departures from the linear response case for already experimentally reachable pulse parameters. An important next step in this approach is the implementation of additional levels next to the 1s - 2p transition. This way, we can describe multiple non-resonant transitions and study transient shifts of energy levels as well as light-induced coupling in pump-probe scenarios. Particularly, their influence on CDI experiments is currently unknown as these effects are usually measured in the gas phase in attosecond transient absorption experiments [3].

[1] D. Rupp et al., Nat. Commun. **8**, 493 (2017)
[2] B. Kruse et al., J. Phys. Photonics **2**, 024007 (2020)
[3] P. Birk et al., J. Phys. B: At. Mol. Opt. Phys. **53** 124002 (2020)

A 14.3 Wed 11:15 A-H1

Towards Two-Dimensional Spectroscopy in X-Ray Quantum Optics — •Lukas Wolff and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Advanced spectroscopic techniques based on the precise control of timing and phase properties of light pulses are well-established throughout the long-wavelength part of the electromagnetic spectrum. In the recent past, considerable progress has also been achieved in the x-ray and XUV-regime. In the hard x-ray regime where the implementation of such control schemes is still challenging, Mößbauer nuclei featuring exceptionally narrow resonances can be employed to split light from modern high-brilliance coherent x-ray sources into double-pulses with characteristic spectral features. High-precision control of the relative phase between these double-pulses was demonstrated recently using fast mechanical motion of nuclear targets.

Here, we propose a new technique for the analysis of 2D spectra obtained via time- and frequency-resolved measurements in the hard x-ray regime using a tunable Mößbauer reference absorber and exploiting mechanical phase control. To demonstrate advantages and limitations of the approach, we extract spectral properties of ensembles of Mössbauer nuclei from simulated data. Our findings may help to pave the way towards studies of more complex spectral structures or nonequilibrium phenomena in Mößbauer science.

A 14.4 Wed 11:30 A-H1

Fast resonant adaptive x-ray optics via mechanically-induced refractive-index enhancements — •Miriam Gerharz and Jörg Evers — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

In this project we introduce a concept for fast resonant adaptive x-ray optics. Using piezo-control methods, we can displace a solid-state target much faster than the lifetime of its resonances. This creates a mechanically-induced phase shift, that can be associated with an additional contribution on resonance to the real part of the refractive index while the imaginary part remains unchanged. Hence, we can achieve polarization control by mechanically-induced birefringence without changes in absorption. We theoretically and experimentally demonstrate the approach with a x-ray polarization interferometer, in which the interference is controlled by the mechanically-induced birefringence. This setup can be used for temporal gating and provides a sensitive tool for a noise background analysis on sub-Ångstrom level.

A 14.5 Wed 11:45 A-H1

Reconstruction of s-state radial wave functions from photoionization cross-section data — •Hans Kirschner, Alexander Gottwald, and Mathias Richter — Physikalisch-Technische Bundesanstalt, Abbestraße 2-12 D-10587 Berlin-Charlottenburg

The atomic photoionization cross-section can be determined by an integral transformation, containing the final and the initial radial state of the unbound and bound electron, respectively. For the calculation of the cross-section, previous works used Hartree-Fock or even more advanced approaches to model the initial electron wave function. We reversed the process and reconstructed s-state initial radial wave functions in real space from photoionization cross-section data of Ne 2s, Ar 3s and Kr 4s in the VUV and soft x-ray region. To evaluate the radial integral, the final state was approximated by a Coulomb wave function. For the initial state, we assumed a linear combination of Slater-type orbitals with adjustable parameters. These parameters were fitted to measurement data through the integral transformation. Markov Chain Monte Carlo methods were applied to receive the best parameter fit with additional probability distributions. With the resulting parameter space the initial radial wave functions with uncertainty was calculated. Density functional theory was consulted for comparison. Despite systematic deviations, the general behavior of the radial wave functions was reconstructed.

A 14.6 Wed 12:00 A-H1

Inner-shell multiple photodetachment of silicon anions — •Ticia Buhr[1], Alexander Perry-Sassmannshausen[1], Michael Martins[2], Simon Reinwardt[2], Florian Trinter[3,4], Alfred Müller[1], Stephan Fritzsche[5,6], and Stefan Schippers[1] — [1]Justus-Liebig-Universität Gießen, Giessen — [2]Universität Hamburg, Hamburg — [3]Goethe-Universität Frankfurt am Main, Frankfurt am Main — [4]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin — [5]Helmholtz-Institut Jena, Jena — [6]Friedrich-Schiller-Universität Jena, Jena

A sensitive tool for studying the interactions between the valence and the core electrons is inner-shell ionization of negative ions. In the present work, m-fold photodetachment (m=3–6) of silicon anions via K-shell excitation and ionization have been experimentally investigated in the photon energy range of 1830 eV to 1900 eV [1] using the PIPE setup [2] at the synchrotron PETRA III. All cross sections exhibit a threshold behavior that is masked by prethreshold resonances associated with the excitation of a 1s electron to higher, either partly occupied or unoccupied atomic subshells. The experimental cross sections are in good agreement with the results of multiconfiguration Dirac–Fock calculations if small energy shifts are applied to the calculated resonance positions and detachment thresholds.

[1] A. Perry-Sassmannshausen *et al.*, Phys. Rev. A **104**, 053107 (2021).
[2] S. Schippers *et al.*, X-Ray Spectrometry **49**, 11 (2020).