Contribution ID: **581** Type: **Contributed talk**

Enhancing Elastic X-ray Scattering via Transient Resonances

Thursday 29 August 2024 12:00 (15 minutes)

X-ray free electron lasers (XFELs) offer the capability to produce ultra-intense (>10e12 photons) and ultra-short (few and sub-femtoseconds) x-ray pulses. The exceptional intensity of these pulses enables the massive ionization of core electronic states, resulting in the creation of transient resonances. Despite the inherent challenge posed by the ultra-fast decay time of these transient states, typically governed by the Auger-Meitner process and lasting 1-2 fs, the brief duration of XFEL pulses allows for the exploration of transient states before their decay. This leads to collective emission phenomena, such as x-ray lasing and x-ray seeded emission spectroscopy. Our investigation focuses on using transient resonances to enhance the elastic scattering factor of individual atoms. Analogous to resonant scattering, where an x-ray pulse with a wavelength matching a core-to-valence transition experiences an increased scattering factor, we utilize a core-to-core transient resonance in this context.

During an experiment at the SCS beamline of EuXFEL, we studied the scattering properties of Cu atoms irradiated by intense XFEL pulses. X-ray pulses are tuned to the Cu-Lα transition (929.7 eV) and focused down to 20 µm onto a 150 nm thick multilayer ([B4C/Cu/SiC]n) target. Photoionization followed by rapid Auger decay produces hot unbound electrons in the sample. A subsequent cascade of electron-electron collisions generates highly charged ions with severe depletion of the Cu 3d shell. In a previous transient x-ray absorption experiment of Cu [1], the authors identified an absorption peak below the natural Cu-L3 edge (932.7 eV). This peak results from the resonant 2p-3d excitation (Cu-Lα transition) of the created 3d vacancies. Correspondingly to resonant absorption, the transient 2p-3d resonances reflect in additional resonant elastic x-ray scattering channels. This results in enhanced scattering strength of individual atoms. We demonstrated that the enhancement strongly depends on the intensity of the incoming pulse and can grow to one order of magnitude. Our findings encourage the application of the effect in innovative crystallographic methods where 3d metals may act as heavy scatterers in analogy with single-wavelength anomalous dispersion.

In this contribution, I will introduce the fundamental concept behind the enhanced resonant elastic scattering (ERES) process. Furthermore, I will present the results of the experiment conducted at the SCS beamline of the European XFEL, where we pursued ERES in a copper-based target.

[1] Mercadier L. et al., Preprint, 2023, 10.21203/rs.3.rs-2396961/v1.

I plan to submit also conference proceedings

Yes

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