Exploiting Transient Resonances in Nonlinear X-Ray Experiments

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X-ray free electron lasers (XFELs) produce ultra-intense and ultra-short X-ray pulses, opening unprecedented opportunities for exploring highly transient states of matter. Among these, the creation of transient resonances through massive ionization of core electronic states enables access to new regimes of nonlinear X-ray interactions, despite the femtosecond-scale lifetime of these resonances. In this contribution, I will present a general overview of the role of transient resonances in nonlinear X-ray scattering, imaging, and spectroscopy experiments, highlighting both theoretical predictions and experimental achievements in the field. I will then focus on our recent work at the SCS beamline of the European XFEL, where we observed enhanced resonant elastic scattering (ERES) from copper atoms via the exploitation of a core-to-core transient resonance at the Cu-Lalpha transition. Our findings illustrate the potential of using transient resonances to boost scattering signals, offering new perspectives for innovative crystallographic methods based on 3d metals acting as heavy scatterers.