Ionization dynamics and electronic structure of x-ray heated plasmas

Oliver Humphries[1], Calum Prestwood[1,2], Thomas Preston[1], Hae Ja Lee[3], Bob Nagler[3], Sam Vinko[4], Mikhail Mishchenko[1], Ulf Zastrau[1], Michal Šmíd[5]

[1]European XFEL, D-22869 Schenefeld, Germany
[2]School of Mathematics and Physics, Queen's University Belfast, Belfast BT71NN, UK
[3]SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA
[4]Department of Physics, University of Oxford, Oxford OX1 3PU, UK
[5]Helmholtz-Zentrum Dresden-Rossendorf, D-01328 Dresden, Germany

I will present on recent experiments at the European XFEL, using the intense x-ray pulse to isochorically heat 3d metals to 100's of eV [1]. Details of the volumetric heating process of the nanofocused XFEL will be discussed, and the ways in which these prototypical systems can inform laser-driven experiments to benchmark models in well-defined conditions. The resulting x-ray emission and inelastic x-ray scattering – as well as resonant variants – of these plasmas will be detailed, along with the information we can extract on the electronic structure and rates.

Through a combination of experimental diagnostics, I will present a picture of how we are able to use the XFEL to diagnose L- and M-shell collisional rates in hot dense systems, and the time evolving ionization balance. A comparison will be made to resonant spectroscopy data using a high-intensity laser driver in conjunction with the XFEL on Cu foil targets, elucidating the difficult-to-model range of spatiotemporal scales needed for even ultra-short optical laser interaction, and how x-ray-only experiments have informed its analysis.

References

[1] M. Šmíd *et al.* arXiv preprint arXiv:2406.06233 (2024)
[2] O. S. Humphries *et al.* Physical Review Letters 125.19 (2020): 195001
[3] T. Gawne *et al.* Physical Review E 108.3 (2023): 035210.