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Single-shot multi-keV X-ray absorption spectroscopy using an ultrashort laser wakefield accelerator source[1]

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X-ray absorption spectroscopy can provide a wealth of information regarding the structure and state of a sample. Techniques such as XANES (X-ray Absorption Near Edge Structure) and EXAFS (Extended X-ray Absorption Fine Structure) provide a simultaneous measurement of the temperature and structure of both the electronic and ionic distributions. Making these measurements using a single ultrashort probe pulse provides a powerful tool for investigating, for example, laboratory-based high energy-density samples. These states are notoriously difficult to probe due to their extreme conditions, transient nature, and often limited shot rate. We present high-resolution single-shot K-edge XANES measurements of a cold titanium sample from a recent experiment using a laser wakefield accelerator source at the Gemini laser facility [1]. $1.2 \pm 0.2 \times 10^6$ photons/eV where generated in the 5 keV region with a smooth broadband spectrum, a signal-to-noise ratio of approximately 300 : 1, and a few femtosecond pulse duration. We demonstrate that this source is capable of single-shot simultaneous measurements of both the electron and ion distributions in matter heated to eV temperatures by comparison with density functional theory simulations. The unique combination of a high-flux, large bandwidth, few femtosecond duration x-ray pulse synchronized to a high-power laser will enable key advances in the study of ultrafast energetic processes such as electron-ion equilibration and non-thermal phase transitions.

References:

1. B. Kettle et al. Phys. Rev. Lett. 123, 254801 (2019)

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