Contribution ID: **109** Type: **Invited oral**

High Energy Density FEL Science

Wednesday 27 June 2018 15:30 (30 minutes)

When solid-density matter is irradiated on 100-fsec timescales with a tightly-focussed x-ray FEL the intensities are such that the electrons are heated to temperatures of several hundred eV or more. Core holes induced in the system via photoionisation by the FEL rapidly fill and, depending on the FEL photon energy and intensity, radiation is only emitted during the FEL pulse itself: the photon energies are too great for thermal emission. In this case a time-integrated spectrum can reveal remarkable information about the state of the solid-density plasma on time-scales shorter than that required for an atom to move much further than a lattice spacing: the heating is truly isochoric.[1]

We report here on experiments where such an x-ray FEL was incident on solid targets. The samples emit copious $K-\alpha$ radiation from the various ion stages present during the heating process. However, the radiation for a given stage is only produced strongly when the photon energy of the incident FEL exceeds the K-edge energy of the ion (or is on a resonance), allowing an accurate measurement of the ionisation energy. We find that the ionisation potential is significantly depressed beyond that predicted by simple models used in many atomics-kinetics calculations,[2] but is in good agreement with calculations based on density-functional-theory.[3] Further recent detailed study of the x-ray spectra emitted by such targets, especially when pumping a K-shell resonance, allows us to glean information on the femtosecond collisional ionisation rates by 'clocking' to the Auger rate.[4]

More recent studies have shown that the x-ray laser is capable of isochorically heating very thin solid density targets, just a few hundred atoms across. The solid-density plasmas produced are extremely close to LTE conditions, and the x-ray laser is sufficiently stable and reproducable that the variation of emission with target thickness allows a measure of both the source function and opacity to be gleaned accurately from the data.[5]

We therefore find that the study of x-ray laser heated solid targets is affording a significant increase in our ability to create, control and probe dense plasmas in regions of temperature and density space where, owing to the competition between thermal and coulomb energies, current understanding is limited.

1. S.M. Vinko *et al.*, Nature, **482**, 59 (2012).
2. O. Ciricosta *et al.*, Phys. Rev. Lett. **109**, 065002 (2012).
3. S.M. Vinko, O. Ciricosta and J.S. Wark, Nat. Comm. **5**, 3533 (2014).
4. Q. van den Berg *et al.*, Phys. Rev. Lett. **120**, 055002 (2018)
5. T. Preston *et al.*, Phys. Rev. Lett. **119**, 085001 (2017)

Primary author: WARK, Justin (University of Oxford)

Presenter: WARK, Justin (University of Oxford)

Session Classification: Matter under extreme conditions