Ultrafast x-ray absorption spectroscopy of warm dense matter

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The detailed properties of matter at very high temperature (above 5000 K) and near-solid density are a challenge for experiments due to the extreme nature of these conditions. Successful experiments must investigate this "warm dense matter" as a transient state. For static or quasi-static samples, x-ray absorption spectroscopy (XAS) has been proven as a powerful tool for investigating the electronic structure of materials. By extending techniques of XAS to the picosecond time domain, it is possible to gain valuable information on the electronic properties of warm dense matter.

Work performed at the Advanced Light Source in Berkeley, California has demonstrated picosecond time-resolved XAS on two high-temperature, dense systems: liquid silicon[1] and liquid carbon. In these experiments, picosecond x-rays from a synchrotron probe the transient absorption spectrum of a thin foil immediately after heating with a femtosecond laser pulse. Heated silicon is observed to be a metallic, highly disordered liquid that compares well to models based on molecular dynamics simulations. The transient XAS of heated carbon allows us to study the fraction of π-bonded atoms in the material as a function of density at temperatures above the melting threshold. This fraction is much larger than that observed in solid forms of carbon, and it is in agreement with the most recent models of the structure of liquid carbon.

Future experiments will be performed at the new μ-XAS/FEMTO beamline at the Swiss Light Source in Villigen, Switzerland. I will show preliminary results from the commissioning of this source.

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[1] S.L. Johnson, P.A. Heimann, A.M. Lindenberg, H.O. Jeschke, M.E. Garcia, Z. Chang, R.W. Lee, J.J. Rehr, and R.W. Falcone, "Properties of Liquid Silicon Observed by Time-Resolved X-Ray Absorption Spectroscopy", Phys. Rev. Lett, **2003**, 91, 157403.