Keynote Lecture

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Progress in laser-driven high-pressure methodology and applications

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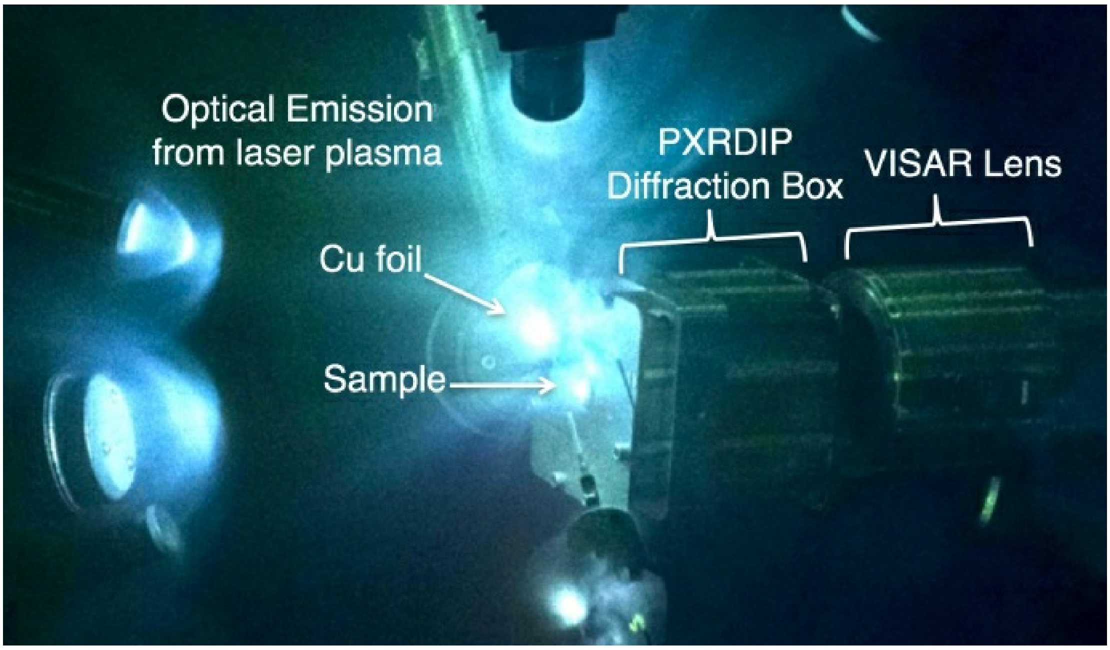
Laser-driven compression experiments have improved over the past 20 years from very exciting (but with large uncertainty) stress-density equation of state (EOS) experiments to diverse, highly-accurate shock and ramp-compression experiments. I will briefly review a range of high-energy density (HED) EOS measurements now possible on large lasers including Hugoniot measurements above 50 (even 500 Mbar) and recent nearly-isentropic absolute EOS measurements to 5-30 Mbar with ~1% accuracy. Laser-pulse shaping allows us to supplement traditional HED measurements of stress-density with shock reflectivity, temperature, sound speed, Gruneisen parameter, and specific heat, as well as crystal structure, and phase transition measurements on shocked, multi-shocked, and ramp-compressed materials.

Dynamic x-ray diffraction has become routine at large lasers like Omega and NIF. I will present an overview of our diffraction results using these lasers on a wide variety of materials at pressures nearing 20 Mbar. In particular, we are studying solid-solid, solid-liquid, and liquid-solid phase transitions, the time-dependent response of phase transitions, the use of textural information to gain insight into mechanisms, and measurements of the Debye-Waller factor by diffraction and EXAFS.

Historically, the availability of laser drivers necessary to perform these experiments has been very limited--primarily accessible only to National Laboratory employees and their collaborators in several countries. This situation will soon change with the upcoming commissioning of moderate-size lasers (P>5 Mbar) at LCLS, SACLA, APS, EXFEL, and ESRF which will open the field of laser-driven compression experiments to all qualified researchers. I will present some of our recent results from experiments from MEC@LCLS and DCS@APS. It is likely that measurements of the kinetics (dynamics) of phase transitions, the radial-distribution function of shocked liquids, short and long range order of both solids and liquids, determination of the temperature of materials under ramp compression, and detailed time-evolving spatial structure of shock fronts and shocked materials, will all come to pass within the next few years. I will discuss the experimental design and diagnostic requirements necessary to obtain the high-quality, accurate results that will make laser-driven compression a field attractive and open to the broad scientific community.

The image below shows a time-integrated photo of a diffraction shot at the Omega Laser in Rochester, NY.



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