ESRF	**Experiment title:** X-ray spectroscopy in laser driven shock generated Warm Dense Matter	**Experiment number**: HD-627
Beamline: ID24	**Date of experiment**: from: 29/04/2014 to: 27/05/2014 (beamtime from 20/05/2014 to 27/05/2014)	**Date of report**: 26/02/2015
Shifts: 18	**Local contact(s)**: Dr. MATHON Olivier	*Received at ESRF:*

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Report:

The experiment was performed at the energy dispersive x-ray absorption beamline ID24, where a portable 35J Quantel laser was installed. The maximum energy of the laser was 35J, delivered in a square pulse of 10ns. The diameter of the laser focal spot was around 350 µm and 90 µm with and without a phase plate respectively. The laser repetition rate was 45 sec. The laser and the X-ray beam hit the target respectively at 45˚ and at 90˚ with respect to its surface.

The data shown in Fig.1 right are spectra acquired with a laser power $I = 2\ 10^{12}\ W/cm^2$; a phase plate was used to obtain a homogeneous spatial profile. The X-rays spot size was 5 µm x 90 µm (HxV). Synchronization between the laser and the x-ray pulse was obtained by visualizing both signals on a diode. The delay between the two signals then was varied to probe the changes occurring as the shock wave propagated through the sample. The arrival of the shock wave into the thin Fe foil was clearly observed through the XANES modifications (red spectra) which indicate the transformation to the high pressure hcp structure. This laser-induced shock state lasted for at least 4 ns in agreement with hydrodynamic simulations as also shown in Fig.1. This is a quite large temporal window compared to the x-ray pulse length (100ps), the probed state is therefore thermodynamically well defined and unaffected from border effects. The reproducibility of the spectra is quite good all along this interval.

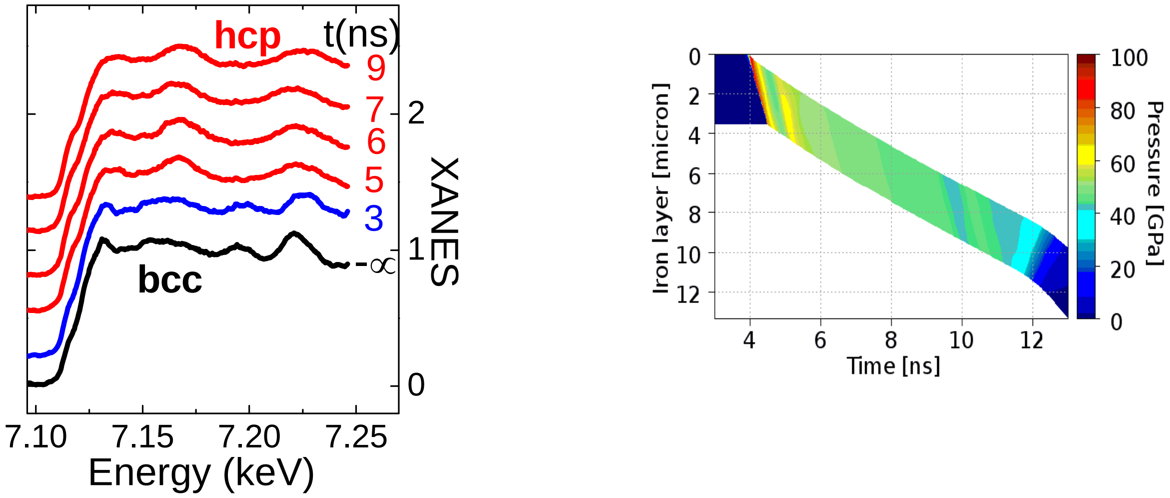

Fig.1: left: spectra acquired with a laser power I= 2 10^{12} W/cm^2 as a function of laser-x-ray delay; hydrodynamic simulation

By slightly modifying the beamline optics geometry the EXAFS range could be extended up to k=8.5. Fig.2 top panel shows some EXAFS spectra acquired up to laser power of 4 10^{12} W/cm2. A quantitative analysis of the EXAFS using a simple two shell model enabled to evaluate compression as a function of laser power density.

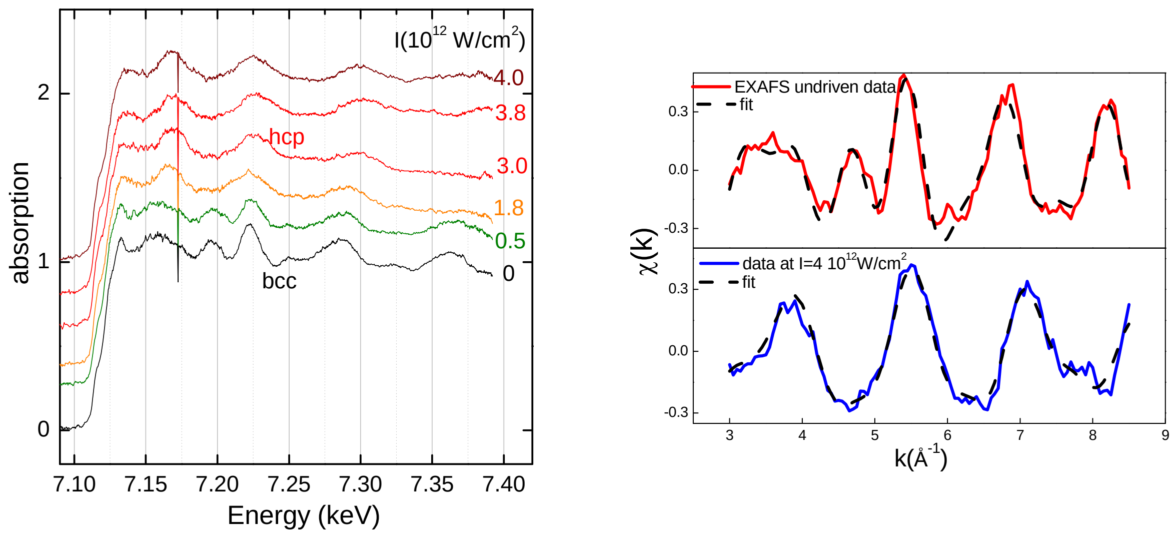

Figure2: left panel: EXAFS measurement of the target as a function of laser intensity, the observable EXAFS range is k=0-8.5 (Å^{-1}). Right panel: fit to the EXAFS function of an ambient and a shocked spectra.

In order to reach higher laser power density, we removed the phase plate and focused the laser to 90 µm and an additional vertically focusing mirror was used to achieve an X-ray focal spot of to 5x7 µm (HxV). In

these conditions we are confident that the probed region is far smaller than that shocked by the laser. In this case targets with thinner diamond windows (25 µm) were used in order to limit the 2D effects.
Data were acquired with laser power density up to I=5 10^{13} W/cm^2, corresponding to P=550 GPa and T=12000K according to hydrodynamic simulations.

A selection of normalized data is shown in Fig.3 top panel.

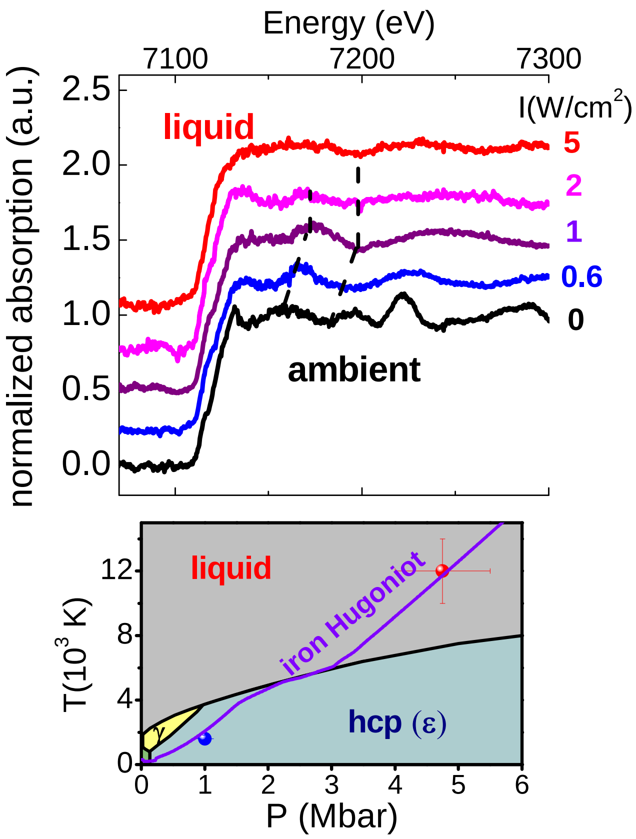

Figure 3: top panel: EXAFS spectra of the target acquired with laser power up to 510^{13} W/cm^2 allowing to follow a trend to the liquid phase. Bottom panel: iron phase diagram showing the explored region in the solid (blu circle) and in the liquid (red circle) phase.

Using a portable 35J laser, solid-solid and solid-liquid phase transitions of iron under extreme pressure and temperature could be induced and observed using single pulse XANES and EXAFS. The quality of the data collected on shocked Fe is similar to that obtainable at ambient conditions. This first experiment demonstrates the feasibility of these studies at a synchrotron beamline, and opens many exciting opportunities for probing the local and electronic structure in very dense states of matter.
These results have been shown in several inteernational conferences and a paper is in preparation.