Contribution ID: **150** Type: **Invited oral**

Iron and Iron alloys under extreme conditions for geoscience application

Wednesday, June 27, 2018 3:00 PM (30 minutes)

An accurate knowledge of the properties of iron and iron alloys at high pressures and temperatures is crucial for understanding and modelling planetary interiors. While Earth-size and Super-Earth Exoplanets are being discovered in increasingly large numbers, access to detailed information on liquid properties, melting curves and even solid phases of iron and iron at the pressures and temperatures of their interiors is still strongly limited. In this context, XFEL sources coupled with high-energy lasers afford unique opportunities to measure microscopic structural properties at far extreme conditions. Also the achievable time resolution allows the shock history and phase transition mechanisms to be followed during laser compression, improving our understanding of the high pressure and high strain experiments.

Here we present recent studies devoted to investigate the solid-solid and solid-liquid transition in laser-shocked iron and iron alloys (Fe-Si, Fe-C and Fe-O alloys) using X-ray diffraction, X-ray diffuse scattering and X-ray absorption spectroscopy. Experiment were performed at the MEC end-station of the LCLS facility at SLAC (USA) and at the EH5 end-station of the SACLA facility (Japan). Detection of the diffuse scattering allowed the identification of the first liquid peak position along the Hugoniot, up to 4 Mbar. The time resolution shows ultrafast (between several tens and several hundreds of picoseconds) solid-solid and solid-liquid phase transitions. Future developments at XFEL facilities will enable detailed studies of the solid and liquid structures of iron and iron alloys as well as out-of-Hugoniot studies and will extend our current knowledge to further extreme pressure.

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Session Classification: Matter under extreme conditions