Dynamic compression experiments with the new High Energy Density Science (HED) instrument at the European XFEL

Markus Schölmerich*[1], Karen Appel[1], Thomas Tschentscher[1], Ulf Zastrau[1], and Ronald Redmer[2]

[1]European XFEL – Holzkoppel 4, 22869 Schenefeld, Germany
[2]Universität Rostock - Institut für Physik – Universitätsplatz 3, 18051 Rostock, Germany

Abstract

With the use of the new experimental facility, the High-Energy Density Science (HED) instrument at the European XFEL it will be possible to investigate matter at extreme conditions like those found inside of exoplanets (Appel et al., 2014; Tschentscher et al., 2017). We will be able to study the model system MgO at pressures of up to 1 TPa and several 1000 K through the temporal pulse shaping capability of the optical laser DIPOLE100X, which will allow quasi-isentropic compression of material, reaching off-Hugoniot high pressure states. These states will help us understand the basic compositional and structural properties of large, terrestrial exoplanets, so-called 'Super-Earths'. Sample design will consist of polycrystal MgO to be deposited as successive coatings directly on a pressure window (LiF). Typical thickness of the sample should be varying from a few μm up to a maximum of 20 μm to ensure homogenous pressure distribution. Specific heating procedures during the process of deposition will enhance the XRD signal. Experimental results will be compared to *ab initio* hydrodynamic simulations to benchmark experimental key phases at the relevant conditions (Cebulla and Redmer, 2014). Ultimately, we are going to obtain equation-of-state (EOS) data for MgO including its melting curve. First simulations via the hydrocode *ESTHER* (Colombier et al., 2005) reveal experimental conditions, in which peak pressures of $>$ 6 Mbar and temperatures of more than 10000 K can be achieved for MgO of 5 μm thickness, a 200 μm square pulse, pulse durations of 5 ns, incident beam angle of 20 degrees and consequently laser intensities of over 7e13 W/cm2. The experimental achieved P-T conditions will be equivalent to those in the inner Earth and in larger rocky planets and ultimately help to understand the compositional and structural properties within these objects.

*Speaker