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Bridging the gaps with the Diamond Anvil Cells on the High Energy Density instrument at the European X-ray Free Electron Laser

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A novel high-pressure platform utilizing diamond anvil cells (DAC) paired with a free electron laser has been established at a High Energy Density (HED) instrument of the European X-ray Free Electron Laser and is in operation since 2019 [1]. A variety of experimental approaches have been implemented including X-ray heating, nanosecond NIR laser heating, piezo-driven DAC compression with X-ray diffraction and X-ray emission techniques [2,3]. In particular, X-ray heating is a novel promising alternative to the standard laser heating techniques to reach high temperatures. In this approach, trains of multiple X-ray pulses separated by 222 or 444 ns gradually increase temperature of the sample by photon absorption of the X-ray pulses coming at the rate faster than the cooling rates given by the transport properties of the sample assembly and the diamond anvils. The unique time structure of the EuXFEL X-ray pulses allows us thus to vary pressure-temperature conditions and probe the state of matter at the same time on the timescales which are between those achievable in the standard laser heating DAC and shock compression experiments.

In this talk, I will report on examples of the first results from many international communities worldwide who performed experiments at the HED instrument and contributed to the scientific excellence in this new research field. Through this large scientific collaboration, new opportunities opened up to study dynamics of structural changes, chemistry, metastability and electronic spin states of materials under deep planetary conditions.

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