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Resolving Ultrafast Heating of Dense Cryogenic Hydrogen

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We performed an XUV-pump XUV-probe experiment on warm dense hydrogen with sub-picosecond time resolution at the XUV free-electron laser facility (FLASH) at DESY (Hamburg). Ultra-fast impulsive electron heating was initiated by a ≤ 300 fs short photon pulse at 92 eV energy. A second XUV pulse probed jitter-free the heated sample via x-ray scattering at variable time delays. We showed that the initial molecular structure dissociates within (0.9 ± 0.2) ps. This allowed to infer the energy transfer rate between electrons and ions. We evaluated Saha and Thomas-Fermi ionization models in radiation hydrodynamics simulations, predicting plasma parameters that were subsequently used to calculate the static structure factor. A conductivity model for partially ionized plasma was validated by two-temperature density functional theory coupled to molecular dynamic simulations, and agreed with our experimental data. Our results [1] provide important insights and the needed experimental data on transport properties of dense plasmas.

[1] U. Zastrau et al., PRL 112, 105002 (2014)

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