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Studying materials under extreme states of high-energy density compression[1]

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Properties of materials under extreme conditions are of key interest to a number of fields, including planetary geophysics, material science and inertial confinement fusion (ICF). In geophysics, the equations of state (EOS) of the planetary materials such as hydrogen and iron under ultrahigh pressure and density will provide a better understanding of their formation and interior structure. [1, 2] Most of these processes are under extreme condition of high pressure (100 GPa to 100 TPa), high temperature (>3000 K) and high strain rates ($>10^5$ s^{-1}). With the advent of high energy density (HED) facilities such as the National Ignition Facility, LCLS and Z, these conditions are reachable and numerous experimental platforms have been developed. To measure compression under ultrahigh pressure, stepped targets are ramp-compressed, and the sound velocity difference measured by VISAR are used to deduce the EOS for various materials on magnetic facilities [3] and on lasers. [4] To measure strength under high pressure and strain rates, the growth of Rayleigh-Taylor instabilities is measured using face-on radiography. [5] The crystal structure of the material under high compression is measured by the dynamic diffraction. [6] Medium range material temperatures (a few thousand degrees) can be measured by EXAFS [7], whereas more extreme temperatures are measured by X-ray Thomson scattering. This tutorial will cover the scientific motivations, experimental techniques, and a discussion of the regimes that can be probed for the study of materials under extreme HED compression.
[1] P.M. Celliers, Science 361, 677 (2018); [2] R.F. Smith, Nat. Astron., 2, 452 (2018); [3] M.D. Knudson, AIP Conf. Proc. 1426, 35 (2012); [4] A. Benuzzi-Mounaix, PPCF 48, B347 (2006); [5] H.-S. Park, PRL 114, 065502 (2015); [6] J.R. Rygg, RSI 91, 043902 (2020); [7] Y.Ping, PRL, 111, 065501 (2013).

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