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High-energy density experiments on planetary materials using high-power lasers and X-ray free electron laser

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Laser-driven dynamic compression allows us to investigate the behavior of planetary and exoplanetary materials at extreme conditions. Our high-energy density (HED) experiments for applications to planetary sciences began over five years ago. We measured the equation-of-state of cryogenic liquid hydrogen under laser-shock compression up to 55 GPa. Since then, various materials constituting the icy giant planets and the Earth-like planets have been studied using laser-driven dynamic compression techniques. Pressure-volume-temperature EOS data and optical property data of water and molecular mixtures were obtained at the planetary/exoplanetary interior conditions. Silicates and oxides data show interesting behaviors in the warm-dense matter regime due to their phase transformations. Most recently the structural changes of iron were observed for understanding the kinetics under the bcc-hcp transformation phenomena on a new HED science platform coupling power-lasers and the X-ray free electron laser (SACLA). This work was performed under the joint research project at the Institute of Laser Engineering, Osaka University. It was partially supported by a Grant-in-Aid for Scientific Research (Grant Nos. 20654042, 22224012, 23540556, and 24103507) and also by grants from the Core-to-Core Program of JSPS on International Alliance for Material Science in Extreme States with High Power Laser and XFEL, and the X-ray Free Electron Laser Priority Strategy Program of MEXT.