Insulator to electronic conductor transition of synthetic planetary ices at interior conditions of icy giants compressed by laser-driven shock wave

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Ices in the universe are consisting of hydrogen, oxygen, carbon, and nitrogen. These elements coalesced to develop into icy giant planets such as Uranus and Neptune in the solar system, as well as some water planets occurring in extrasolar planetary systems. Properties of such planetary ices at elevated pressures and temperatures are essential clues for understanding the layering structures and material circulations inside these giants. Here by using high-power nanosecond laser pulses from GEKKO-XII glass laser at Institute of Laser Engineering at Osaka University, such ices of several compositional types are dynamically compressed, where their equation-of-state (P-V-T) and optical reflectivity (R) are measured at in situ conditions using fast optical diagnostics (Figure). We have successfully observed the transition from insulator to electronic conductor state of the planetary ices which include carbon and/or nitrogen components, as well as that transition of pure H2O ice observed by our previous work [1]. We have also observed the transition at off-Hugoniot conditions using a sample-precompression technique with a diamond anvil cell, which was effectively coupled with laser-driven shock to increase the shock-pressure and to decrease the shock-temperature. These results provide us a new insight about the nature of conducting media inside the icy giants and about the origin of magnetic fields from deep inside of them.
[1] T. Kimura, N. Ozaki, T. Sano, T. Okuchi, et al., J. Chem. Phys., 142, 164504 (2015).

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