Abstract for an Invited Paper
for the MAR07 Meeting of
The American Physical Society

Laser-driven shock studies on planetary ices

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Planetary ices such as water, methane and ammonia make up the bulk composition of planets such as Uranus and Neptune. Additionally, extra-solar planets recently discovered may also be partially composed of these ices. Due to their shear size, the interiors of these planets are at simultaneous high pressures and temperatures. Using laser-driven shock compression, experiments at these extreme conditions—up to $\sim$10 TPa pressures currently and up to $\sim$100 TPa (1 Gbar) in the near future—is possible and covers the full range of planetary pressures, including "super-giant" extra-solar planets. Additionally we can couple the dynamic compression with that of static compression in a diamond-anvil cell in order to decrease the temperatures along the principal Hugoniot. Laser-driven shock compression of water samples pre-compressed to 1 GPa produces high-pressure and high-temperature conditions inducing two significant changes in the optical properties of water: the onset of opacity followed by enhanced reflectivity in the initially transparent water. The onset of reflectivity at infrared wavelengths can be interpreted as a semi-conductor $\leftrightarrow$ electronic conductor transition in water, and is found at pressures above $\sim$130 GPa for single-shocked samples pre-compressed to 1 GPa in contrast to pressures above $\sim$100 GPa for water samples without precompression. Our results indicate that conductivity in the deep interior of "icy" giant planets is greater than realized previously because of an additional contribution from electrons.