Using Sandia's Z Machine and Density Functional Theory Simulations to Understand Planetary Materials

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The high-pressure behavior of planetary materials has implications for numerous geophysical and planetary processes. The continuing discovery of exotic exosolar planets demonstrates the need for accurate equation of state data in regimes well beyond those found in the Earth's interior. In addition to planetary structure, hypervelocity collision processes, such as the moon-forming giant impact, require accurate equation of state models over a wide-range of pressures, temperatures, and even phases. Using shock compression techniques, we can generate the high-pressures relevant to these problems. Shock compression experiments on Sandia's Z machine, the National Ignition Facility (NIF), and the Omega Laser platforms have produced many breakthrough results for the planetary sciences.

In this talk, we will review basic methods of shock compression and then overview modern platforms, such as Sandia's Z machine, that can generate several hundreds of GPa of pressure. While dynamic compression techniques explore thermodynamic regimes unattainable with static methods, they often do not provide a complete picture a material's response because of the short timescales and violent nature of the experiments. At Sandia, we combine dynamic compression experiments with *ab-initio* calculations to elucidate material properties and phase transitions at high pressures and temperatures. Using the combination of Z experiments and density functional theory based quantum molecular dynamics simulations, we have examined the shock response of several important geophysical materials including CO_2, MgO, and Mg_2SiO_4. The combination high-precision experimental measurements with *ab-initio* calculations provides a solid basis for understanding material behavior at extreme conditions.

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