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Exploring Extra-Solar Planetary Interiors: New Chemistry at Extreme Conditions

DYLAN SPAULDING, Commissariat a l'energie atomique

The physical and transport properties of silicate and oxide melts at extreme pressures and temperatures are critical for understanding early planetary evolution and the aftermath of late-stage giant impacts such as that believed to have formed the Moon. Here we report on a suite of laser-driven shock experiments on major mineral phases of significance to the terrestrial mantle and extra-solar rocky planets SiO2, MgO and MgSiO3. Experiments on two polymorphs of SiO2 were used to validate experimental technique and are compared to previous results. We extend Hugoniot equation of state measurements for MgO and MgSiO3 to 6.4 and 9.5 Mbar, respectively, constraining controversial predications for the ultra-high pressure melt curves. Experiments on amorphous and crystalline MgSiO3 starting materials show the first evidence of a liquid-liquid phase transition with a volume reduction of 5-8% near 3.5 Mbar and over a range of temperature of at least 7000 K, suggesting the potential for unexpectedly complex chemistry in silicate liquids. Transport properties are extracted from time-resolved optical reflectivity data and imply that the distinction between silicate and metallic constituents are blurred in deep planetary interiors with potential implications for coupling across the present-day core-mantle boundary.