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Hugoniot Measurements of Diamond and α-Quartz in the TPa Regime: Implications for Astrophysics, ICF, and HED Physics[1]

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The development of an ultra-high velocity ($>$ 40 km/s) flyer plate capability at the Sandia Z Machine has enabled TPa shock wave experiments with unprecedented accuracy. Here we present the results of Hugoniot measurements on diamond and z-cut, α-quartz in the 0.5-1.5 and 0.1-1.6 TPa regime, respectively. The diamond measurements are inclusive of a large solid-liquid coexistence region, and together with quantum molecular dynamics (QMD) calculations, provide compelling evidence for the existence of a diamond-bc8-liquid triple point along the Hugoniot. The new quartz Hugoniot data reveal significant errors in the current, widely-used quartz standard and have immediate ramification for the equations of state of deuterium, helium, and diamond at pressures relevant to giant planets and other high energy density conditions. This work provides a foundation for the use of quartz as an extremely accurate standard for use in multi-Mbar shock wave experiments, as well as a benchmark for first-principles calculations of high-pressure material response where processes such as disorder, dissociation, and ionization are significant.

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