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New Frontiers at the Intersection of Shock Physics and Planetary Sciences

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The field of planetary science has exploded with the discovery of over 500 confirmed extrasolar planets and many more candidate planets, almost all larger than Earth. The physical characteristics of extrasolar planetary systems and individual planets differ significantly from our Solar System, leading to fundamentally new ideas about the physics of planetary accretion and the internal structure and evolution of planetary bodies. Understanding the greatly expanded pressure-temperature space of observed planets presents an exciting opportunity and challenge to the high-pressure research community. I illustrate these opportunities with a discussion of recent work on the physics of giant planetary collisions and the internal structures of large rocky bodies called Super-Earths. The terminal collision defining the end of accretion leaves an indelible mark on the final physical and dynamical properties of a rocky planet. For example, in the Solar System, giant collisions are invoked to explain the observed variations in bulk compositions, spin orientations, and satellite systems; in extrasolar systems, recent giant impacts have left behind telltale trails of dust and gas. Using Mbar shock and release experiments, my colleagues and I have measured the liquid-vapor curve of silica. Similar measurements are needed on other important geologic phases to determine the mass of shock-produced vapor during impact events and to develop multiphase equation of state models. Recent work on modeling giant impacts has focused primarily on the dynamics in order to investigate the hypothesized impacts that formed the Moon and stripped Mercury of its silicate mantle. Testing these hypotheses and generalizing our understanding of planet formation requires major advances in equation of state and rheological models. Planetary collisions and interiors provide a unifying area of study for many disciplines within the high-pressure community, including equations of state, strength and fracture, chemistry, and multiphase flows.