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Recreating planetary interiors in the laboratory by laser-driven ramp-compression[1]

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Recent advances in laser-driven compression now allow to reproduce conditions existing deep inside large planets in the laboratory. Ramp-compression allows to compress matter along a thermodynamic path not accessible through standard shock compression techniques, and opens the way to the exploration of new pressure, density and temperature conditions. By carefully tuning the laser pulse shape we can compress the material to extremely high pressure and keep the temperature relatively low (i.e. below the melting temperature). In this way, we can probe solid states of matter at unprecedented high pressures. This loading technique has been combined with diagnostics generally used in condensed matter physics, such as x-ray diffraction and x-ray absorption spectroscopy (EXAFS, Extended X-ray Absorption Fine Structure, in particular), to provide a complete picture of the behavior of matter in-situ during compression. X-ray diffraction provides a snapshot of the structure and density of the material, while EXAFS has been used to infer the temperature. Simultaneous optical velocimetry measurements using VISAR (Velocity Interferometer for Any Reflector) yield an accurate determination of the pressure history during compression. In this talk I will present some of the results obtained in ramp-compression experiments performed at the Omega Laser Facility (University of Rochester) where the phase maps of planetary relevant materials, such as Fe, FeO and MgO, have been studied to unprecedented high pressures. Our data provide experimental constraints on the equations of state, strength and structure of these materials expected to dominate the interiors of massive rocky extra-solar planets and a benchmark for theoretical simulations. Combination of these new experimental data with models for planetary formation and evolutions is expected to improve our understanding of complex dynamics occurring in the Universe.

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