Ramp compressed Iron at Super-Earth interior conditions

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Recent investigations of the mass-radius relationship of solid exoplanets indicate they consist of iron, silicates, water, and carbon compounds. The accurate equation of state (EOS) at Super-Earth interior conditions is fundamental to evaluate the composition and interior structure. The conditions in these rocky Super-Earths interiors reach 1-4 TPa and ~10^4K and cannot be easily achieved by a single shock or quasi-isentropic compression in laboratory experiments.
Here we developed laser shock and ramp compression techniques to perform a series of experiments on Fe-LiF targets initially shocked and then ramped using shaped laser pulses in the high-powered laser facility of China. In the present experiments, the initial shock pressure was nearly 300 GPa to provide high temperature for achieving interiors conditions. The peak ramp pressures were more than 1 TPa, comparable to that predicted at the center of Super-Earths. By the Lagrangian sound-speed analysis for the measured VISAR data, we determined pressure, density and sound speed along the isentropic path at these extreme condition. Our EOS data were also compared with the previous ones to know the effects of the initial shock pressure and temperature. Finally, our results provide directly-measured key physical properties of iron at the extreme high pressure and temperature, which can be used to model the physics and chemistry of iron and to understand the structures and dynamics of the cores of Super-Earths.

Keywords: Iron, High Pressure, Laser shock compression, Super-Earth interior, Equation of State