Crystal structure of Fe-Si alloys at TPa pressures

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The recent discovery of thousands of planets outside our Solar System [1, 2] has prompted research into the material properties of geologically-relevant minerals at pressures well in excess of those found in the interior of Earth [3, 4]. As super-Earths – rocky extrasolar planets with masses up to 10 times that of Earth – have core pressures that are predicted to be as high as 4000 GPa (4 TPa), a better understanding of the high pressure and temperature response of the constituent materials is essential to understanding the internal structure and properties of these planets.

Recently developed dynamic compression techniques with high-powered lasers allow solid-state material properties to be measured at TPa pressures [5, 6]. The ramp compression approach and associated low temperature compression path is key to studying materials at pressures relevant to planetary interiors while maintaining the solid state. Here, we discuss experiments conducted on the Omega laser facility located at the University of Rochester's Laboratory for Laser Energetics, where we measured the crystal structure of Fe-Si alloy with the goal of understanding the effect of silicon on the structure and density of exoplanetary cores.

Using up to twenty five beams of the Omega laser we combine the techniques of ramp compression and nanosecond x-ray diffraction to measure the structure of Fe-7wt%Si and Fe-15wt%Si alloys to 1250 GPa. High pressures were achieved by focusing temporally-shaped laser drives onto target packages containing Fe-Si alloys, while in situ x-ray diffraction probed the structure at maximum compression.

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