Equation of state of Fe and Fe-Si under core conditions of large rocky exoplanets

R.F. Smith

Lawrence Livermore National Laboratory, Livermore, USA

The discovery of large numbers of planets outside our solar system has been one of the most exciting scientific discoveries of this generation. Of the over 4000 confirmed and candidate extrasolar planets, those that are 1-4 times the radius of the Earth are now known to be the most abundant. This size range, which spans between Earth and Neptune, is not represented in our own solar system, indicating that planets form over a wider range of physical conditions than previously thought. Planets are common, with at least one-quarter of Sun-like stars having a 1-2 Earth-radius planet. These discoveries raise fundamental questions: What are the different types of extrasolar planets and how do they form and evolve? Which of these objects can potentially sustain surface conditions suitable for life? To address such questions, it is necessary to understand the composition and interior structure of these objects. As core pressures for even a 5×-Earth-mass planet can reach as high as two million atmospheres (2 TPa), a fundamental requirement for constraining exoplanetary composition and interior structure is an accurate determination of the material properties at extreme pressures. Iron is a cosmochemically abundant element and as the dominant constituent of terrestrial planetary cores is a key material for studying 'super-Earth' interiors. In this talk we describe a new generation of high-power laser experiments, which uses quasi-isentropic ramp-compression techniques to provide the first absolute equation of state measurements of Fe at the extreme pressure and density conditions found within super-Earth cores. We also describe recent x-ray diffraction experiments to determine the crystal structure of FeSi alloys at TPa pressures.