CAREER: Phase Diagrams and Elasticity of Iron Alloys in the Earth's Core

Because of its remoteness, together with extremely high pressures and temperatures, most direct observations of the Earth's core properties have come from teleseismic studies, requiring large earthquake sources and well-positioned seismometers to detect weak wave signals that have traversed through the Earth's deepest interior. In the last two decades, deep-Earth scientists have unveiled a number of unusual and enigmatic phenomena of the core, including inner core anisotropy, differential rotation of the inner core, fine–scale seismic heterogeneity, and the possible existence of the prefer-orientated iron alloys in the inner core. Understanding these phenomena will help test hypotheses on the Earth's formation, elucidate the geochemistry and the history of the Earth's deep interior, and determine the dynamic behavior of Earth's solid inner core and liquid outer core. This CAREER award investigates the alloying effects of major candidate light elements on the phase diagram and elasticity of iron under relevant pressures and temperatures of the core in order to address pressing issues on its compositions, thermal structures, and seismic features. Working together with theorists and experimentalists, results from this award will ultimately be used to construct a forward model for the expected velocities, compositions, and temperature profiles in the core. The thermoelastic modeling aspects of the proposal will provide students and postdoctoral researchers with a great opportunity to collaborate with scientists in the fields of seismology and geodynamics, helping them understand how laboratory mineral physics data are applied to deep-Earth issues and what kinds of new data are most urgently needed by the community.

The proposed mineral physics research uses synchrotron X-ray spectroscopies in a laser-heated diamond anvil cell designed to probe structural and elastic properties of iron alloys at pressure-temperature conditions of the Earth's core. Under the initiatives of the projects, students and postdoctoral researchers will have unique research opportunities to use advanced synchrotron X-ray facilities at the Advanced Photon Source to obtain laboratory results needed to decipher seismic and geochemical observations of the planet's core. This will contribute to the education of the next generation of independent researchers with a thorough knowledge of the Earth's deep interior. Outreach activities in this CAREER award focus on exposing K-12th graders to deep-Earth research by involving in the outreach summer programs. A collection of displayable materials with information about deep-Earth research will be made available to students and teachers in the Austin School Districts to support the dissemination of accurate scientific knowledge and enthusiasm. Results from this award will be disseminated broadly through teaching, seminars, conferences, and peer-reviewed publications.