Multi-scale structures and thermal constraints at Earth's core-mantle boundary

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The large chemical, density, and dynamical contrast associated with the juxtaposition of a liquid iron-dominant alloy and an intimate mixture of silicates and oxides at Earth's core–mantle boundary is associated with a wide range of complex seismological features. Interpretation of these multi-scale features and the dynamic processes that formed them requires, in part, knowledge of the thermoelasticity and melting properties of candidate phases. We will present recent nuclear resonant and x-ray scattering measurements on iron-bearing phases and the application of these results to our understanding of Earth's core and core-mantle boundary region [e.g., 1-8]. The nuclear resonant inelastic x-ray scattering method provides specific vibrational information, e.g., the partial projected phonon density of states, while the elastic scattering method (synchrotron Mössbauer spectroscopy) provides information on hyperfine parameters, e.g., oxidation and spin states. The high statistical quality of the data in combination with in-situ x-ray diffraction permits accurate evaluation of the equations of state, vibrational-related parameters pertaining to iron-bearing materials, such as the sound velocities, vibrational entropy and free energy, Grüneisen parameter, thermal pressure, and iron isotope fractionation quantities. Finally, we will present constraints on the temperature of the core-mantle boundary using a new method of melt-detection using synchrotron Mössbauer spectroscopy and a fast temperature readout spectrometer. Our approach is unique because the dynamics of the atoms are monitored prior to melting, while temperatures are determined accurately and precisely. We will discuss the implications of our results as they relate to the composition and dynamics of various structures near Earth's core-mantle boundary.

Select References

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