Elasticity of Earth's deep interior probed by Inelastic X-ray Scattering

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In recent years inelastic x-ray scattering (IXS) has been proven to be a very useful technique for the investigation of lattice dynamics of materials under extreme thermodynamic conditions. In this talk I will illustrate present capabilities of IXS as a tool for the experimental study of elasticity of minerals and geophysically relevant materials at high pressure and high temperature, complementing more classical methods such as ultrasonic techniques and light scattering, particularly in the critical case of opaque samples.

Two examples will be discussed, highlighting the differences between measurements on single crystals and polycrystalline samples.

As first example I will present measurements of the complete elastic tensor of $(Mg_{0.83}Fe_{0.17})O$ ferropericlase at pressures across the spin crossover [1]. While a distinct softening of the shear modulus C_{44} occurs across the spin transition, along with a small variation for C_{12}, the longitudinal modulus C_{11} retains a continuous evolution. The obtained density dependence of the aggregate compressional and shear sound velocities does not show any significant deviation from a linear trend, providing a clear explanation for the lack of any one-dimensional seismic signature in the lower mantle directly related to the spin crossover. The spin state transition does, however, influence shear anisotropy of ferropericlase and should contribute to the seismic shear wave anisotropy of the lower mantle.

In the second example I will review sound velocity measurements in polycrystalline iron and iron alloys at high pressure and high temperature. The measured aggregate compressional and shear sound velocities, extrapolated to core densities and corrected for anharmonic temperature effects, are compared with seismic profiles. These results suggest a model that simultaneously matches the primary seismic observables, density, P-wave and S-wave velocities, for an inner core containing 4 to 5 wt.% of Ni and 1 to 2 wt.% of Si [2].

References:
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