Elasticity of Iron Alloys in Earth's Inner Core

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Earth's solid inner core is mainly made of Fe with approximately 5% of Ni and a few weight percent of light elements. Knowledge about the elastic properties of Fe and its alloys under relevant pressure-temperature conditions is thus crucial for understanding seismic observations and help constrain the composition of the Earth's core. Recent seismic observations have shown that Earth's inner core exhibits 3-4% anisotropy in the compressional-wave velocities (Vp) which may be a result of the existence of the textured iron alloy crystals, whereas evidence for the shear-wave (Vs) anisotropy and splitting is emerging. Furthermore, comparison between seismic models of the core and elasticity of iron alloys at relevant conditions provides a reliable means to estimate the composition of the region. Here we have measured the sound velocities (Vp and Vs) and their anisotropies of iron alloys at unprecedented pressure-temperature conditions core using synchrotron inelastic x-ray scattering spectroscopies coupled with diamond anvil cells. Our results on textured hcp-Fe up to 172 GPa show that hcp-Fe exhibits 2-4 % Vs anisotropy, with the c axis being the fastest direction and the a axis the slowest. Together with the measured Vp anisotropy of hcp-Fe, the results are used to understand the seismic anisotropies of the inner core. We have also measured the Vp-density relation of hcp-Fe and Fe-Si alloy at high pressure-temperature conditions simultaneously using *in situ* high-energy resolution inelastic x-ray scattering and x-ray diffraction coupled with external heated diamond cells. Combining our results with a thermodynamic modeling and seismic observations, we report a new sound velocity model of hcp-Fe that calls for more light elements in the inner core than previous models without considering the temperature effect. Our results on the elasticity of iron alloys are used to critically evaluate seismic and geochemical models of the inner core, providing new insights into understanding seismic anisotropies and compositions of the Earth's inner core.