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Sound velocity measurements of dhcp FeHx up to 70 GPa by inelastic X-ray scattering

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The Earth's interior has been directly investigated by seismic wave propagation and normal mode oscillation. In particular, the distributions of density and sound velocity are available to study the Earth's core (e.g. PREM). The inner core, which is solid state, is approximately 3 % less dense than pure iron (a core density deficit), and it is considered that the core consists of iron and light elements, such as hydrogen, carbon, oxygen, silicon, and sulfur.

Hydrogen could be supplied to the Earth's core in the form of iron hydride (FeHx), which could have been formed by reaction between iron and water during the core formation. The compressibility and sound velocity of FeHx has been measured up to 80 GPa by X-ray diffraction (XRD) experiment (Hirao et al., 2004) and up to 52 GPa by nuclear resonant inelastic X-ray scattering (NRIXS) (Mao et al., 2004), respectively. The NRIXS experiment can determine the Debye sound velocity (VD), but can not directly determine the compressional velocity (Vp) and the shear velocity (Vs). In order to calculate Vp and Vs, it is needed to use the bulk modulus and the density measured by XRD experiment at high pressure. Therefore, in this study, we directly estimated Vp of FeHx by inelastic X-ray scattering (IXS).

The IXS experiments and in situ XRD experiments were conducted up to 70 GPa and room temperature. High-pressure conditions were generated using a symmetric diamond anvil cell (DAC) with tungsten gaskets. Hydrogen initially pressurized to 0.18 GPa was loaded to the sample chamber at National Institute for Materials Science, Japan. The IXS experiments were performed at BL35XU beamline of the SPring-8 facility in Japan. We used the Si (9 9 9) configuration, which provides an incident photon energy of 17.794 keV with an energy resolution of 2.8 meV full width at half-maximum (FWHM). The XRD experiments at high pressure were carried out by the angle dispersive method at BL10XU beamline of the SPring-8 facility in Japan. The each XRD pattern of FeHx was collected after each IXS measurement in order to obtain directly the density of FeHx.

Over the range of pressure studied, the diffraction lines of double-hexagonal close-packed (dhcp)-FeHx were observed and there were no diffraction lines of iron. We show FeHx follows Birch's law for Vp above 37 GPa, namely a linear dependence between velocity and density.

Keywords: inelastic X-ray scattering, iron hydride, core, high pressure