

Sound velocity measurements of liquid Fe-Ni-S alloy at high pressure and temperature via inelastic X-ray scattering

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The liquid Earth's outer core is mainly composed of Fe-Ni alloy with some amounts (5~10%) of light element(s), such as hydrogen, carbon, oxygen, silicon, and sulfur. Moreover, it has been known that the Mars and Mercury have also liquid (outer) core, although there are less observational data (Dehant, 2003, Margot et al., 2007).

In order to identify the kind and amount of the light elements dissolved in these planetary cores, sound velocity data of iron alloys at high pressure and temperature are important because the seismic wave speeds are the primary observed information in the deep Earth's interior. While sound velocity measurements of solid core materials up to core pressures have been extensively conducted via ultrasonic method, inelastic X-ray scattering (IXS), nuclear resonance IXS, due to its experimental difficulty, there exist few reports on sound velocity measurements of liquid Fe alloys at high pressure (Nishida et al. 2012).

We measured sound velocity of liquid of (Fe,Ni)₃S up to 30 GPa. Sulfur has been considered to be a major candidate for the light element in the Earth's outer core as well as in the Martian and Mercury's cores (e.g. Lodders and Fegley 1997). We conducted high-pressure and -temperature experiments with an externally-heated diamond-anvil cell (EHDAC). The starting materials were a synthesized or a powder mixture of Fe, Ni, and FeS, with compositions of (Fe_{0.83}Ni_{0.17})₃S, or (Fe_{0.64}Ni_{0.36})₃S. Sound velocity was measured using high resolution IXS at BL35XU, or BL43XU of SPring-8. IXS spectra were collected in the range of the momentum transfer, $Q=3.2\text{?}6.59\text{ nm}^{-1}$ with a resolution of 0.45 nm^{-1} . EHDAC was put in a vacuum chamber to reduce the background of the spectra. We will present the sound velocity data of liquid and solid of (Fe,Ni)₃S and discuss the composition of the terrestrial, Martian, and Mercury's liquid outer core.

Keywords: sound velocity, inelastic X-ray scattering, planetary outer core, liquid iron alloy, High-PT experiment