Sound velocity of liquid Fe-P alloy at high pressure

*Yoichi Nakajima[1,2], Daisuke Kinoshita[3], Yasuhiro Kuwayama[4], Kei Hirose[5,4], Asaki Iwamoto[3], Daisuke Ishikawa[6], Alfred Q.R. Baron[2]

1. POIE, Kumamoto Univ., 2. RIKEN MDL, 3. Grad. School Sci. Tech., Kumamoto Univ., 4. Dept. Earth Planet. Sci., Univ. Tokyo , 5. ELSI, Tokyo Tech. , 6. JASRI

The compositions and physical properties of planetary cores are of great importance to understand the core formation processes, the thermal and chemical evolutions, and the present-day core dynamics. Terrestrial planets such as Mercury, Mars, as well as Earth are believed to have molten cores that consist of Fe alloys with lighter components such as hydrogen, carbon, nitrogen, oxygen, silicon, phosphorous, and sulfur [1]. Therefore, the physical property of liquid Fe alloys with possible lighter elements at high pressure relevant to the core conditions is key to understanding the planetary cores. Phosphorous is one of the candidates for the light elements in planetary cores because iron phosphorous alloys such as schreibersites (Fe_3P) and allabogdanite (Fe_2P) are often found in chondrites and iron meteorites [2,3]. Here we report the P-wave velocity of liquid Fe-P up to 96 GPa based on inelastic X-ray scattering (IXS) measurements.

We performed IXS measurements at the Quantum NanoDynamics beamline (BL43LXU) [4] of the RIKEN SPring-8 Center. The sample of $Fe_{75}P_{25}$ together with single crystal Al_2O_3 thermal insulators was compressed by a diamond-anvil cell (DAC), and then melted using the laser-heating system installed at the beamline. The longitudinal acoustic phonon mode of the liquid was measured in a momentum transfer range of 3-6 nm^{-1}. The P-wave velocity of liquid $Fe_{75}P_{25}$ was determined up to 96 GPa based on the phonon dispersion relation obtained at each pressure condition. Based on the P-wave velocity determined at high pressures, we constructed the equation of state for liquid $Fe_{75}P_{25}$. We found that the influence of phosphorous on the sound velocity of liquid Fe [5] is almost negligible under the present experimental pressure conditions, while the phosphorous reduces the bulk modulus and density of liquid Fe.

References:

[1] D.J. Stevenson, Science **214** 611–619 (1981).
[2] R. Skála and I. Císařova. Phys. Chem. Miner. **31**, 721-732 (2005).
[3] S.N. Brítvin et al., Am. Mineral. **87**,1245-1249 (2002).
[4] A.Q.R. Baron SPring-8 Inf. Newsl. **15**, 14–19 (2010). http://user.spring8.or.jp/sp8info/?p=3138
[5] W.W.Anderson and T.J. Ahrens, J. Geophys. Res. **99**, 4273–4284 (1994).

Keywords: Planetary cores, Liquid Fe alloys, Sound velocity, High pressure

