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Measurements of Equation of State and sound velocity of laser-shocked iron beyond 100 GPa

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Researching the Earth's Interior, Equation of State (EOS) and sound velocity of interior materials are the important physical properties. The Earth's outer core is composed of liquid iron, and it is about from 135 GPa to 330 GPa about from 4000 K to 6000 K. It is technically difficult to generate such high pressure and temperature by static compression technique (e.g. diamond anvil cell). However, since we can generate higher pressure and temperature by dynamic compression technique (e.g. laser), we will be able to measure EOS and sound velocity of iron under the outer core's condition and higher pressure.

We performed laser-shocked experiments of pure iron at GEKKO-HIPER Laser system in Institute of Laser Engineering, Osaka University (ILE). The laser-shocked compression in ILE can generate the pressure over 1TPa, which is higher than that of the earth's outer core. To determine EOS of iron, we measured the shock velocity and particle velocity of iron by VISAR (velocity interferometer system for any reflector). We will obtain them by analyzing the fringe shift of the interference stripes induced by the interface motion of the shock wave. Meanwhile, the sound velocity of iron is obtained by the radiography from the side of target. The moment the shock wave traveled to the target's rear surface, the rarefaction wave propagated through the target and reached the front surface which is the laser-irradiated side, and the whole of targets were accelerated. The rarefaction wave propagates the target with the sound velocity.

In this experiment, the shock pressure was about from 100 GPa to 200 GPa in the case of the EOS measurements of pure iron and was over 400 GPa in the case of the sound velocity measurements of pure iron in this experiment. We obtained the data of the EOS and the sound velocity from the VISAR and the radiography.

Keywords: iron, laser-shocked compression, Equation of State, sound velocity, the Earth's outer core