Elasticity and Phonon Dispersion in hcp-Metals at High Pressure

ANTONANGELI D., ARACNE C.[1], BADRO J.[2], FARBER D.[2], OCCELLI F.[2], REQUARDT H., FIQUET G.[1] AND KRISCH M.

European Synchrotron Radiation Facility, France; [1]Lawrence Livermore National Laboratory, USA ; [2]Laboratoire Minéralogie-Cristallographie, Université Paris VI, IPGP, France

Understanding the effects of pressure on the propagation of elastic waves is singularly important for many fundamental and applied physical issues. For example, the possibility to produce detailed models of the internal structure of the Earth and other planets, critically hinges on our knowledge of the pressure dependence of sound velocities and elastic moduli.

The experimental study of elasticity in materials under high-pressure remains extremely challenging even with the large variety of techniques that are currently being employed. Amongst these, Inelastic X-ray Scattering (IXS) is particularly well suited to high pressure, and furthermore is capable of mapping the complete phonon dispersion curves.

Here we report new IXS data from polycrystalline hcp-iron and single crystal hcp-cobalt as a function of pressure. Our choice of these materials is based on the crucial importance of iron to the elasticity and elastic anisotropy of Earth's inner core, while our study of cobalt is motivated by its similar elastic and thermal properties to iron, with the advantage to be available as single crystals.

In the case of iron, taking advantage of the texturing developed by uniaxially compression [1], and making use of a properly designed diamond anvil cell, we measured the longitudinal sound velocity at 22 and 112 GPa in two different geometries (at 50° and 90°) with respect to the compression axis. The difference in the acoustic sound velocity is about 4-5% at the highest pressure. This effective anisotropy is comparable with the seismologically observed difference in propagation within the Earth's core (3-4%). The derived longitudinal and transverse sound velocities allow us to extend and complete previous IXS results [2].

In the case of cobalt, we determined the pressure dependence of all five independent elastic moduli to 39 GPa. Based on these data, we derived the elastic anisotropy in the meridian (a-c) plane. Our experimental results compare favourable with first principle calculations [3].

Further plans and perspectives are discussed, as well as the present capabilities of IXS at high pressure.

References

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