Synchrotron studies change understanding of the composition of Earth's core

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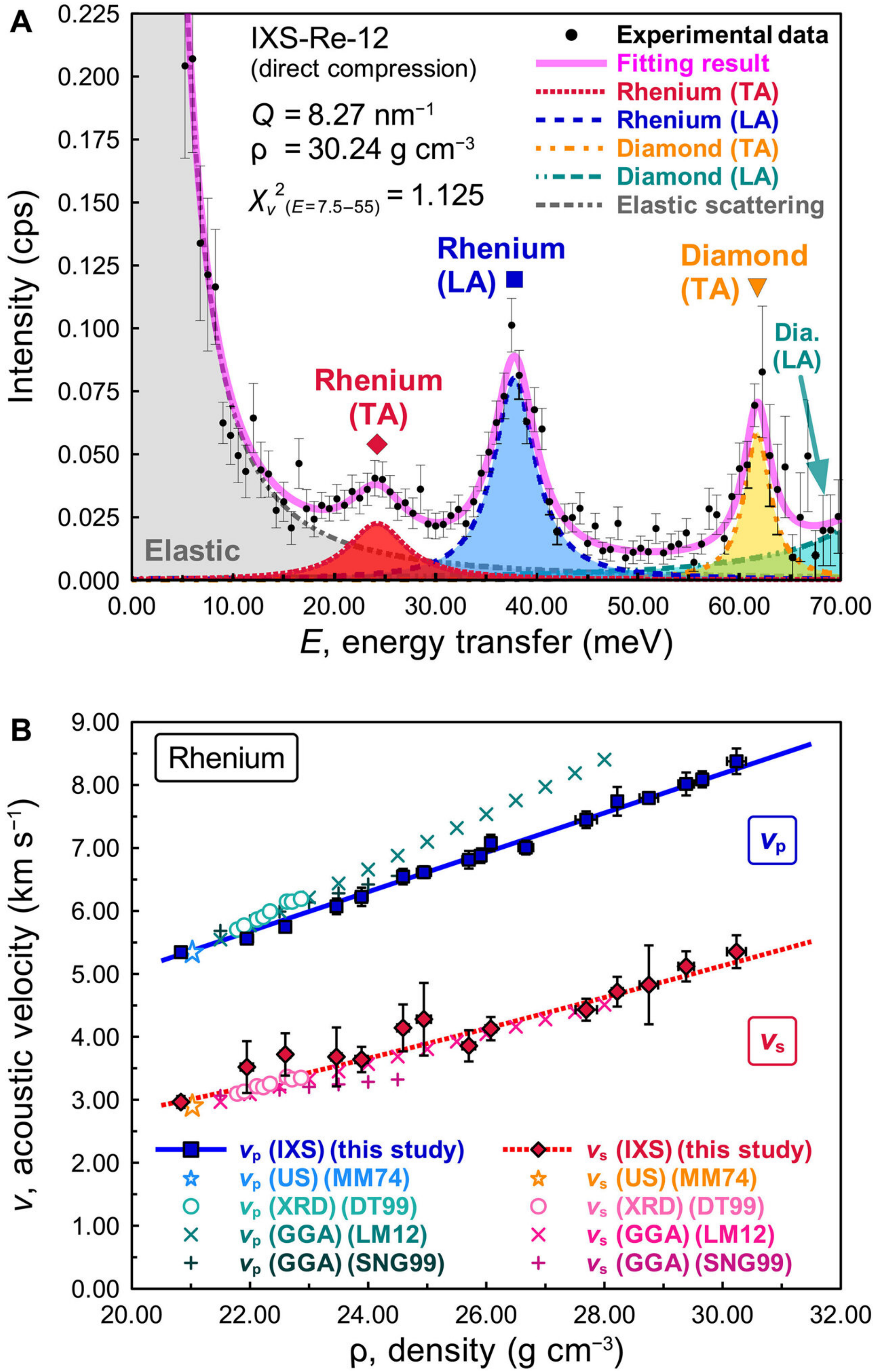
A
IXS-Re-12
(direct compression)
Q = 8.27 nm⁻¹
ρ = 30.24 g cm⁻³
χv² (E=7.5–55) = 1.125
Experimental data
Fitting result
Rhenium (TA)
Rhenium (LA)
Diamond (TA)
Diamond (LA)
Elastic scattering
Rhenium (LA)
Diamond (TA)
Dia. (LA)
Rhenium (TA)
Elastic
Intensity (cps)
E, energy transfer (meV)
B
Rhenium
vp
vs
vp (IXS) (this study)
vs (IXS) (this study)
vp (US) (MM74)
vs (US) (MM74)
vp (XRD) (DT99)
vs (XRD) (DT99)
vp (GGA) (LM12)
vs (GGA) (LM12)
vp (GGA) (SNG99)
vs (GGA) (SNG99)
v, acoustic velocity (km s⁻¹)
ρ, density (g cm⁻³)

Results of acoustic velocity measurement for rhenium at high pressure.(**A**) IXS spectrum and fitting results for rhenium at density, $\rho = 30.24$ g cm^{-3} (230 GPa) and 300 K (IXS-Re-12). The black dots are the IXS data with 1 SD (1σ) error bars. Other colored lines and areas are individual inelastic contributions of LA and TA modes as labeled, with colored symbols showing the fitted peak positions. (**B**) Acoustic velocities (compressional, v_p, and shear, v_s) for rhenium as a function of density. The blue squares and red diamonds are v_p and v_s for rhenium determined from our IXS data with 1σ error bars. Other colored symbols are from previous studies. Credit: *Science Advances* (2023). DOI: 10.1126/sciadv.adh8706

In work published in *Science Advances*, a team of researchers have determined a new pressure scale, which is critical for understanding the Earth's composition.

Using X-rays from a uniquely powerful spectrometer at RIKEN's SPring-8 Center they avoided some of the large approximations of previous work, discovering that the previous scale overestimated pressure by more than 20% at 230 gigapascals (2.3 million atmospheres)—a pressure reached in Earth's core. This is similar to someone running a marathon that they thought was 42 kilometers, but finding they had only really run 34 kilometers. While 20% might seem like a modest correction, it has big implications.

An accurate pressure scale is critical for understanding the composition of the Earth. In particular, the core composition is hotly debated as it is important both for understanding our planet at present, and for understanding the evolution of the solar system in the distant past. While it is generally accepted that the core is mostly iron, evidence from tracking the propagation of seismic waves from earthquakes suggests the core also contains lighter material.

When the new scale was used to interpret the seismological model, the team found that the amount of light material in the inner core is about double what was previously expected, and indeed the total mass of light material in the entire core is probably five times, or more, that of the Earth's crust—the layer that we live on.

In the new work, the team, led by Alfred Q.R. Baron of the RIKEN SPring-8 Center, and Daijo Ikuta and Eiji Ohtani of Tohoku University, used Inelastic X-ray Scattering (IXS) to measure the sound velocity of a rhenium sample under pressure. A tiny rhenium sample (

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