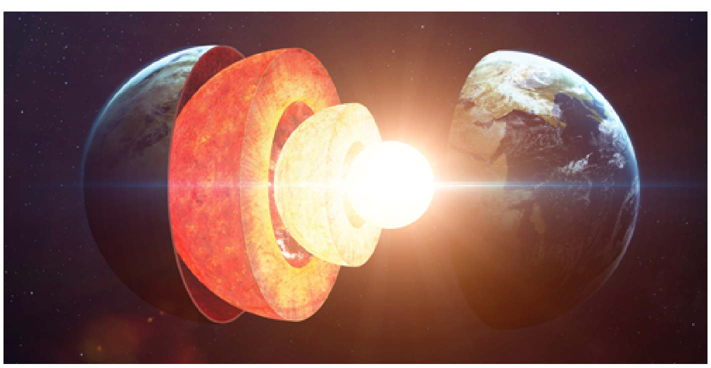
Taking the Temperature of Earth's Core

By measuring the melting temperature of iron under high transient pressure, researchers set a limit on the temperature at the boundary between the inner and outer cores.

By **Marric Stephens**

Understanding Earth's dynamo and other internal processes depends on knowing how iron—the main constituent of Earth's core—behaves under high pressures and temperatures. Researchers have mapped parts of the relevant pressure–temperature phase diagram using a mixture of theory and experiment, but since the most extreme conditions can be produced in the lab only fleetingly (if at all), large gaps and uncertainties remain. Now Sofia Balugani at the European Synchrotron Radiation Facility in France and colleagues have subjected a sample of pure iron to a pressure of 270 gigapascals (GPa)—close to the 330 GPa at the boundary of Earth's inner core—and measured its temperature as it melted [**1**]. Given that the iron in the core is mixed with nickel and other elements, which lower its melting point, the result sets an upper limit on the temperature at the boundary between the solid inner core and the liquid outer core.

Experimenters routinely produce static pressures of many hundreds of gigapascals using diamond-anvil cells. However, pairing these pressures with high temperatures requires a dynamic approach. In previous studies, researchers compressed samples by blasting them with brief, intense laser pulses while characterizing their structure using x-ray diffraction. Balugani and colleagues used laser compression, but they combined it with x-ray absorption spectroscopy, a technique that's sensitive to both structure and temperature.



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Their sample began to melt under 240 GPa at 5345 K. Through extrapolation, the researchers inferred that the temperature at the boundary of the inner core must be no higher than 6202 K. They also ruled out a crystal transition—from hexagonal close-packed to body-centered cubic—which had been predicted to occur near that temperature.

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REFERENCES

1. S. Balugani *et al.*, "New constraints on the melting temperature and phase stability of shocked iron up to 270 GPa probed by ultrafast x-ray absorption spectroscopy," **Phys. Rev. Lett. 133, 254101 (2024).**