

Making Uranian and Neptunian Ice on Earth

Researchers crushed and heated ice between diamond anvils to confirm the existence of a phase of ice that could be present in the warm mantles of ice giants.

By **Charles Day**

In 1986, Voyager 2 flew by Uranus and detected a magnetic field whose dipole was vastly offset from the planet's center and whose axis was vastly offset from the planet's rotation axis. Three years later, the spacecraft discovered that Neptune's field was similar. The most likely origin of the ice giants' magnetic fields involves a mantle of "superionic ice," a phase made up of mobile protons flowing through a lattice of oxygen atoms. Now Alexis Forestier of the French Alternative Energies and Atomic Energy Commission (CEA) in France and his colleagues have created and observed a form of superionic ice that had been repeatedly predicted by theoretical studies [1].

Forestier and his colleagues began each experimental run by using a syringe to squirt ultrapure water into a diamond-anvil cell. To reach the conditions that prevail in the mantles of ice giants, the researchers squeezed the sample while simultaneously heating it with laser light. The temperature ranged from 300 to 2630 K; the pressure ranged from 80 to

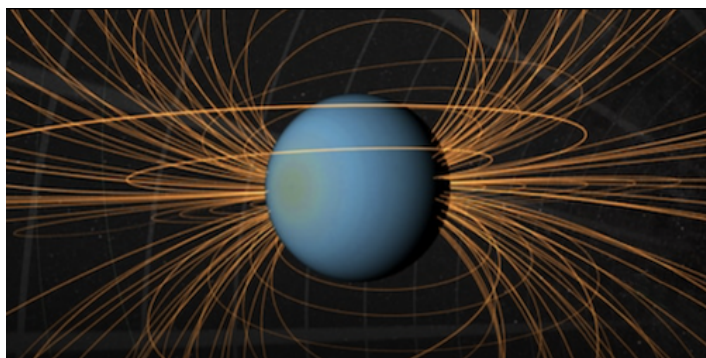
229 gigapascals (GPa). The researchers conducted their investigation at the European Synchrotron Radiation Facility in France, whose Extremely Brilliant Source enabled them to obtain clear diffraction patterns despite the sample being squashed to just 12 μm in diameter.

The diffraction patterns revealed that face-centered cubic (fcc) superionic ice transitions to a hexagonal-close-packed (hcp) form at temperatures above 1800 K and pressures above 160 GPa. Those conditions are within the superionic regime and relevant to ice-giant interiors. The hcp form could have different mechanical- and ionic-conduction properties compared to the fcc phase, so the results could have implications for models of Uranus, Neptune, and their exoplanet brethren.

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REFERENCES

1. A. Forestier *et al.*, "Observation of hexagonal close-packed water ice at conditions in ice giant planetary interiors," *Phys. Rev. Lett.* **137**, 114101 (2026).



Credit: NASA Scientific Visualization Studio