Detecting How Earth Twists Spacetime

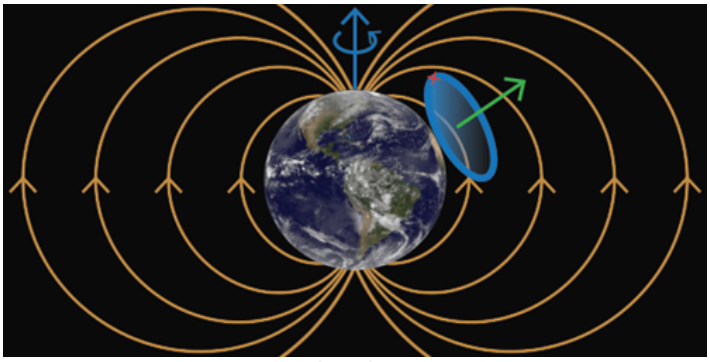
A proposed lab-based quantum sensor could precisely measure within seconds the warping of spacetime caused by Earth's rotation.

By **Ryan Wilkinson**

Einstein's theory of general relativity predicts that Earth's rotation subtly distorts spacetime surrounding the planet. Known as frame dragging, this effect has previously been detected using classical probes onboard satellites. But those measurements were indirect, requiring months or years of data collection and complex modeling of Earth's gravity. Now Birgitta Whaley at the University of California, Berkeley, and her colleagues have proposed a novel Earth-based quantum sensor that could measure frame dragging directly in just a few seconds [**1**]. If realized in the lab, the device would provide a stringent test of general relativity.

Just as a rotating ball of electric charge generates a magnetic field, Earth and other rotating bodies produce a so-called gravitomagnetic field. Like the magnetic field lines of a magnet, Earth's gravitomagnetic field lines flow from one of its poles to the other. These field lines drag surrounding spacetime and cause it to ever so slightly twist.

To measure this feeble phenomenon, Whaley and her colleagues propose using a quantum device in which a loop of ultracold superfluid helium is interrupted by a tiny porous barrier. Frame dragging slightly shifts the quantum phase of the helium flowing through this barrier and, in turn, the device's resonant frequency, enabling the effect to be detected.



Credit: K.-I. Ellers/University of California, Berkeley

The researchers' analysis suggests that their device could resolve the rate of frame dragging to a level of 0.2%, matching the precision of the best satellite data. Depending on the device's quality, this precision could be achieved in minutes or even within one second without relying on intricate modeling or a satellite launch.

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REFERENCES

1. K.-I. Ellers *et al.*, "Quantum sensing of gravitational frame dragging with a superfluid ^{4}He gyrometer," **Phys. Rev. Lett. 137, 121404 (2026).**