frequencies and quality factors of up to 10^7, and silicon nanobeams have been demonstrated[13] with 3.7 GHz resonant frequencies and quality factors of up to 10^5. One question to be addressed in future work is whether a system exists that exhibits both an extremely high resonant frequency and a large quality factor — a combination that would allow many manipulation and read-out steps over the coherence lifetime with no special cooling mechanism. ❒

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SENSING

Giant laser gyroscope detects Earth's wobble

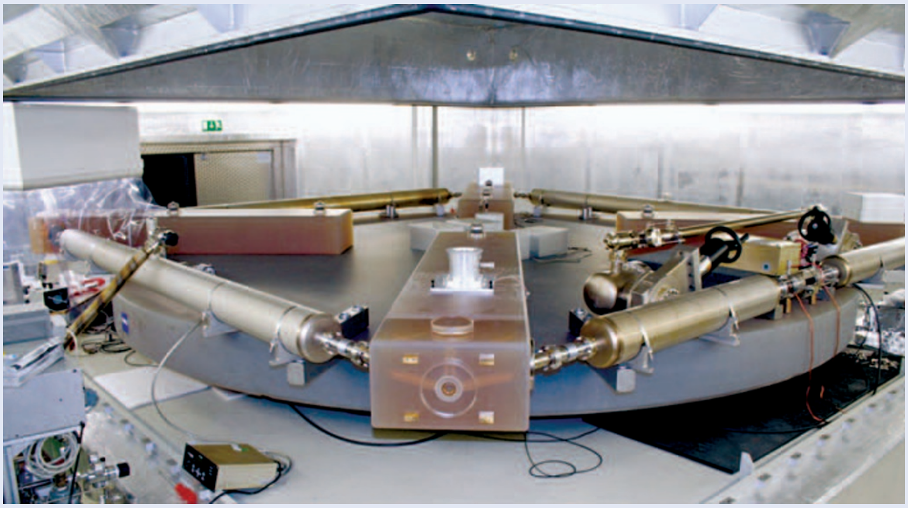
Improvements to the German ring laser gyroscope known as 'G' have allowed scientists to measure the tiny periodic shifts in the Earth's axis of rotation, without needing to rely on complex astronomical observations or GPS satellites (*Phys. Rev. Lett.* **107,** 173904; 2011).

In the late 1800s, American amateur astronomer Seth Carlo Chandler discovered that the Earth's axis of rotation precesses over a period of about 14 months, akin to the way a child's spinning-top wobbles as it rotates. Although this 'Chandler wobble' is small (the geographic north pole shifts by less than 10 m), it is important to take into account for the purposes of precise navigation.

Scientists usually measure the Chandler wobble using schemes such as very-long-baseline interferometry. Although this technique works well, it is expensive, requires a network of telescopes and cannot provide instantaneous readings. Now, scientists from the Technical University of Munich and the Geodetic Observatory Wettzell in Germany and the University of Canterbury in New Zealand have measured the Chandler wobble using a single self-contained optical instrument — a large ring laser gyroscope with 4-m-long arms, called G.

Ring laser gyroscopes sense rotation by exploiting the Sagnac effect, a small frequency difference between laser beams travelling in opposite directions around a ring cavity. Ring laser gyroscopes have become useful tools for use in inertial navigation systems, but their compact size often limits their sensitivity.

G is a large, ultrasensitive HeNe ring laser gyroscope whose custom-built underground surroundings are designed to minimize external disturbances. The ring laser took three years to build and began operation in 2001. In order to optimize its thermal and mechanical stability, the system was built on a 10-tonne base made from a special glass ceramic called Zerodur, which has a very small thermal expansion coefficient of less than 1.4×10^{-8} K^{-1}.



GEODETIC OBSERVATORY WETTZELL

The researchers upgraded G with superior mirrors and encapsulated it within a pressure-stabilizing vessel. This improved the system's sensitivity and stability enough to allow the measurement of fractional changes in rotation as small as 1 part in 10^8. This performance level is sufficient for detecting not only the Chandler wobble but also other small fluctuations in the Earth's rotation. The researchers plan to improve the gyroscope further by using even better mirrors to lower the quantum limit of its sensitivity.

"Although we have successfully measured the Chandler wobble using G, the results are still around half an order of magnitude away from what very-long-baseline interferometry achieves with respect to sensitivity, and more than an order of magnitude away in terms of long-term stability," commented Ulrich Schreiber, a scientist involved in the project.

"The next phenomenon that we could hope to measure is the Lense–Thirring frame-dragging effect [a small change in rotation due to general relativity]. This is particularly challenging because it will require the stability of the system to be improved far beyond its current level."

Interestingly, G is the not the largest ring laser gyroscope ever built. That record belongs to the UG-2 ring laser, which encloses an area of 834 m^2 and is located at Cashmere Cavern in Christchurch, New Zealand.

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