Gyroscope's unexplained acceleration may be due to modified inertia

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(PhysOrg.com) -- When a spinning laser gyroscope is placed near a super-cooled rotating ring, the gyroscope accelerates a bit in the same direction as the ring, and scientists aren't sure why. The anomalous acceleration was discovered in 2007 by Martin Tajmar at the Space Propulsion group at the Austrian Institute of Technology in Seibersdorf, Austria. So far, the effect has only been observed in this one laboratory. Since then, scientists have been looking for an explanation for the so-called Tajmar effect.

In a recent study, Michael McCulloch of the University of Plymouth in the UK has shown that a model that he previously proposed can predict the small unexplained acceleration. His results are published in a recent issue of *Europhysics Letters*.

"[Laser gyroscopes] work by sending light around a circle in both directions, and then measuring the interference of the two opposing light waves," McCulloch told *PhysOrg.com*. "When the gyro is spun/accelerated, the interference pattern changes detectably." Commercial laser gyroscopes that operate this way are currently used in aircraft and missiles for orientation and stabilization.

In this study, McCulloch suggests that the gyroscope's observed acceleration stems from a change in its inertial mass and an attempt to conserve momentum with respect to a supercooled rotating ring. Tajmar's experiments used rings that were cooled to 5K and made of a variety of materials, such as niobium, aluminum, stainless steel, and

TEFLON.

McCulloch proposes that the gyroscope's inertial mass is determined by surrounding Unruh radiation that is modified by a Hubble-scale Casimir effect. In the model, the Unruh radiation is generated by the gyroscope's acceleration relative to every other mass in the universe, such as the fixed stars in the sky and the cold rotating rings. The Hubble-scale Casimir effect is an effect in quantum field theory that, in this case, prohibits the generation of longer Unruh waves, and so indirectly affects the gyroscope's inertial mass. McCulloch calls this model "modified inertia due to a Hubble-scale Casimir effect" (MiHsC) or simply "quantized inertia."

When the gyroscope is at room temperature, it is surrounded by short-wavelength Unruh radiation, and its inertial mass is close to its gravitational mass. When its surroundings are cooled, the gyroscope's inertia becomes more sensitive to the small accelerations of the fixed stars. The wavelengths of the Unruh radiation become longer, and are prohibited by the Hubble-scale Casimir effect, causing the gyroscope's inertial mass to decrease to less than its gravitational mass. However, when the supercooled ring begins to rotate, the ring's larger accelerations cause the Unruh waves to shorten so that fewer waves are prohibited, and the gyroscope's inertial mass increases.

According to the model, in order to conserve momentum, the gyroscope attempts to move with the ring by accelerating in the same direction. For clockwise rotations, the gyroscope should accelerate at a rate of about 2.67×10^{-8} times the acceleration of the ring. For counterclockwise rotations, the gyroscope should accelerate only about half that much.

This model's predictions closely match Tajmar's observations, in which the gyroscope's acceleration was about 3×10^{-8} times that of the ring for clockwise rotations, and half that for counterclockwise ones. MiHsC does not have any adjustable parameters, so it agrees with the observations without being numerically tuned.

McCulloch's model can also explain why the counterclockwise acceleration is smaller than the clockwise one. As the gyroscope starts to spin with the ring, it changes movement relative to the fixed stars. When in the northern hemisphere (where the experiment was performed), this effect causes a greater acceleration when rotating clockwise. But the model predicts that, when performing the experiment in the southern hemisphere, the gyroscope should accelerate more when rotating counterclockwise than clockwise, while still following the ring's rotation.

"Inertial mass has not been well understood and has been assumed to be the same as gravitational mass (the Equivalence Principle, EP)," McCulloch explained. "If MiHsC is correct, then the EP is only an approximation (the small deviation from the EP due to MiHsC could not have been detected in torsion balance experiments, as I explain in the Discussion of my paper). As a result there may be implications for General Relativity since this assumes the EP is true (and therefore also implications for low-acceleration phenomena like the orbits of stars at the edge of galaxies). Inertia is important practically since it determines the sensitivity of an object's motion to outside forces."

As McCulloch explains, the Tajmar effect is closely related to another odd observation: the unexplained acceleration of some spacecraft. For instance, when interplanetary probes fly by the (spinning) Earth, some of them undergo unexplained jumps in velocity. In a previous paper, McCulloch showed that the MiHsC model agrees fairly well with these flyby anomalies if a spacecraft's acceleration is determined relative to all the particles of matter in the spinning Earth. He also showed that the model could explain the Pioneer anomaly: as the two Pioneer spacecraft flew out of the Solar System, they slowed down more than predicted, which can be attributed to the spacecrafts' small decrease of inertial mass, which increased their acceleration toward the Sun.

In the current paper, McCulloch suggests a way to test his model's validity for explaining the Tajmar effect. His model predicts that reducing the mass of the rotating ring by a factor of 10,000 would result in a decrease of the effect with distance. He hopes that Tajmar's group will try this test with lighter rings using their existing equipment. If McCulloch's model holds up, it could potentially prove useful.

"Once the cause of something is known, then it may be controllable," he said. "The control of inertia could be useful. For example: Can we generate Unruh radiation to change the inertial mass of an object and thereby move it? I have discussed this possibility in previous papers (e.g., *EPL*, 90, 29001)."

More information: M. E. McCulloch. "The Tajmar effect from quantised inertia." *EPL*, 95 (2011) 39002. DOI: 10.1209/0295-5075/95/39002