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Physicist says testing technique for gravitomagnetic field is ineffective

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Albert Einstein's theory of general relativity has fascinated physicists and generated debate about the origin of the universe and the structure of objects like black holes and complex stars called quasars. A major focus has been on confirming the existence of the gravitomagnetic field, as well as gravitational waves. A physicist at the University of Missouri-Columbia recently argued in a paper that the interpretation of the results of Lunar Laser Ranging (LLR), which is being used to detect the gravitomagnetic field, is incorrect because LLR is not currently sensitive to gravitomagnetism and not effective in measuring it.

The theory of general relativity includes two different fields: static and non-static fields. The gravitomagnetic field is a non-static field that is important for the understanding of general relativity and the universe.

"If the existence of the gravitomagnetic field is confirmed, then our understanding of general relativity is correct and can be used to explain things such as quasar jets and accretion disks in black holes," said Sergei Kopeikin, associate professor of physics in MU's College of Arts and Science. "General relativity explains the origin of the universe, and that's important for all humankind, irrespective of religion or creed. We all live in the same world, and we must understand this place in which we live."

Kopeikin said there are four techniques used to test for the gravitomagnetic field. The first, called Gravity Probe B, used a gyroscope in orbit around the earth to measure for the field. It is supported by NASA and took nearly 40 years to develop; scientists recently conducted the experiment and are now analyzing the results.

A second experiment involved satellites called Lageos and detected a gravitomagnetic field with a precision not exceeding 15 percent. A third experiment was developed by Kopeikin and other scientists in 2001 and used Very Long Baseline Interferometry (VLBI) to test for the gravitomagnetic field of Jupiter; this experiment detected the field with approximately 20 percent precision.

LLR is a recent testing technique. It involves shooting a laser beam at mirrors called retroflectors, which are located on the moon, and then measuring the roundtrip light travel time of the beam. In a response to a paper about LLR, Kopeikin argued in a letter published in Physical Review Letters that the interpretation of LLR results is flawed. He said analyses of his own and other scientists' research reveal that this approach to the LLR technique does not measure what it claims.

The LLR technique involves processing data with two sets of mathematical equations, one related to the motion of the moon around the earth, and the other related to the propagation of the beam from earth to the moon. These equations can be written in different ways based on "gauge freedom," the idea that arbitrary coordinates can be used to describe gravitational physics. Kopeikin analyzed the gauge freedom of the LLR technique and showed that the manipulation of the mathematical equations is causing scientists to derive results that are not apparent in the data itself.

"According to Einstein's theory, only coordinate-independent quantities are measurable," Kopeikin said. "The effect the LLR scientists claimed as detectable doesn't exist, as it vanishes in the observer's frame. The equations add up to zero, having nothing to do with the real data. The results appear this way because of insufficient analytic control of the coordinate effects in the sophisticated computer code used for numerical LLR data processing. We need to focus on the real physical effects of gravity, not the mathematical effects depending exclusively on the choice of coordinates."

A reply from the scientists who support LLR also has published in *Physical Review Letters* and argues that there are aspects of the technique that cause them to believe it merits worth.

Source: University of Missouri-Columbia

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