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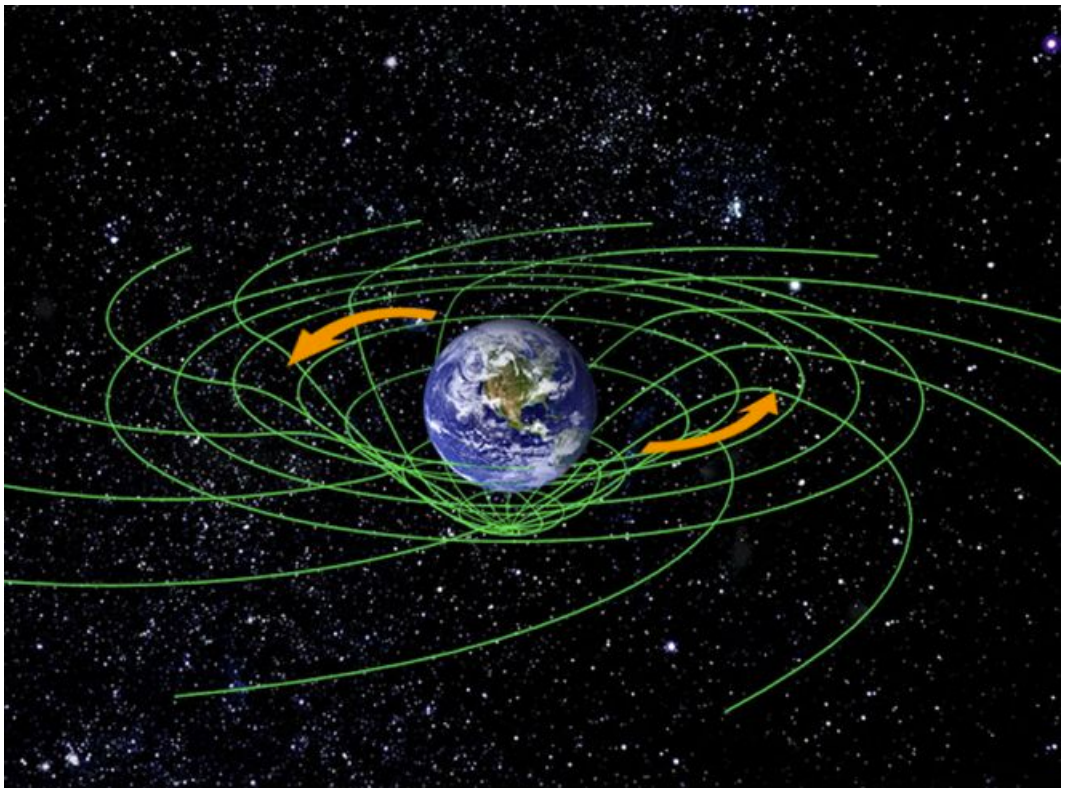
Floating Gyroscopes Vindicate Einstein

By Lisa Grossman ✉ May 4, 2011 | 5:59 pm | Categories: Physics, Space



Four superconducting ping-pong balls floating in space have just confirmed two key predictions of Einstein's general relativity, physicists announced in a press conference May 4.

"We have completed this landmark experiment testing Einstein's universe, and Einstein survives," said physicist Francis Everitt of Stanford University, the principal investigator on NASA's Gravity Probe B mission.

The probe, which launched in 2004, was designed to test the effect Earth's gravity has on the space-time around it. According to Einstein, the Earth warps its local space-time like a bowling ball sitting on a trampoline, a phenomenon called the geodetic effect. This effect means that a circle of fabric with the Earth's circumference, about 24,900 miles, would be pulled into a shallow cone with a circumference 1.1 inches shorter.

The Earth also swirls the nearby space-time around with it as it rotates, like water spiraling around a drain, in an effect called frame-dragging.

"Picture the Earth immersed in honey, and you can imagine the honey would be dragged around with it," Everitt said. "That's what happens to space-time. Earth actually drags space and time around with it."

Both effects are minuscule — Einstein himself wrote that "their magnitude is so small that confirmation of them by lab experiments is not to be thought of." But Gravity Probe B measured them both. The results will be published in *Physical Review Letters*.

The spacecraft orbited the Earth for 17 months carrying four ping-pong ball sized gyroscopes. The gyroscopes were made of fused quartz spheres, which hold the Guinness Book record for "most spherical man-made object." The spheres were covered in a soft metal called niobium and cooled to the temperature of liquid helium.

At that temperature, niobium becomes superconducting, which means that electrons can flow forever without losing energy. When the spheres are set spinning, the circling electrons give rise to a little magnetic pointer.

In Newton's universe, that pointer would point in the same direction forever as the spacecraft circled the Earth. But in Einstein's universe,

where Earth twists and tugs the space-time around it, the gyroscopes' pointer was sent atilt at a sliver-thin angle. The north-south tilt measured the geodetic effect, and the east-west tilt measured frame-dragging.

The pointer shifted by just 6,000 milliarcseconds — the width of a human hair as seen from 10 miles away — over the course of a year, Everitt said. Despite the difficulty in detecting such a small tilt, the physicists were able to confirm the geodetic effect to an accuracy of 0.28 percent, and frame-dragging to within 20 percent.

Because general relativity describes the large-scale structure of the universe, the Gravity Probe B results could help improve physicists' understanding of cosmic phenomena from black holes to gamma-ray bursts, Everitt says.

Gravity Probe B is one of the longest-running NASA projects ever. It started in 1963, before men walked on the moon. It took five decades to develop the technologies to build gyroscopes sensitive enough to see gravitational effects. In the meantime, those technologies found homes in a host of other NASA Earth-observing satellites, plus the Cosmic Background Explorer satellite, which measured the cosmic microwave background and provided Nobel Prize-winning evidence for the big bang.

Physicist Clifford Will of Washington University in St. Louis, head of the external review board for Gravity Probe B, called the research team's efforts "heroic" and stressed the importance of testing fundamental theories of nature, not just taking them for granted.

"It is popular lore that Einstein was right, but no such book is ever completely closed in science," he said. "While the result in this case does support Einstein, it didn't have to."

Image: An artist's rendition of the way the Earth warps space-time, called the geodetic effect. NASA/Gravity Probe B

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Alex Sawka

Nope, he's on the right track. It starts with a step to left....it's called "The Time Warp." Now, if you are REALLY confused (which you may be) go watch Rocky Horror Picture Show

2 hours ago in reply to DrKnowNothing Like Reply

DrKnowNothing

Thanks. Just added to Netflix.

2 hours ago in reply to Alex Sawka Like Reply

Buddha Buck

There's a potential unit-conversion issue going on. 6000 milliarcseconds over 10 miles is about 18.4 inches, not the width of a human hair. One milliarcsecond would be the angle subtended by a skinny human hair when viewed from 10 miles away.

5 hours ago 4 Likes Like Reply

Jack Frigaard

Agreed, 6000 mas over 10 miles (16km) would form an arc of approx 46.81cm.

3 hours ago in reply to Buddha Buck Like Reply

Theodore Blanner

Aren't they refering to the shift in seconds of the gyros? I mean, the thickness of a hair as seen from 10 miles is the size in minutes of a shift in an arc at the size of the gyros. Not a shift in the arc over 10 miles.

1 hour ago in reply to Jack Frigaard 1 Like Like Reply

dajoe

Very cool, but this is one of those stories where the science goes beyond this amateur observer. Part of me thinks they could have measured something else, such as a shifting magnetic field caused by something other than Einstein's theory, and part of me says I should keep my mouth shut lest I be thought a fool.

42 minutes ago 1 Like Like Reply

Nick Westgate

6,000 milli-anythings is 6 somethings.

0 minutes ago Like Reply

Theodore Blanner

I mean that the thickness of a hair as seen from 10 miles is the amount the gyro shifted in an arc the size of a ping-pong ball. Not an arc over a distance of 10 miles?

1 hour ago Like Reply

Abhijit Borah

The age of astronomical/cosmological/fundamental discoveries are finally arriving.

2 hours ago Like Reply

Adam Carter

clean up your computer room, dawg.

26 minutes ago in reply to Abhijit Borah Like Reply

Vin Patel

I think there is a couple of things wrong with the title of this piece. 1) Einstien hasn't been accused of any wrongdoing that needs vindication. 2) its a furthur confirmation rather than a vindication or even a furthur vindication. If a theory is proven wrong by observation, there's nothing underhand about the theory, because when it was proposed it fitted observation at the time. Ok i may be nitpicking and maybe vindicate was used to give the title punch and i'm no expert on science but i think using vindicate conflates science and dogma and that is misrepresentative about the nature of scientific statements.

2 hours ago Like Reply

Sean Lee

Is the frame dragging dependent upon the rotation of the object (the Earth) and/or it's mass? It would be interesting if these results were compared in some manner to more massive objects like Jupiter, the Sun, a Blue Giant Star, and a black hole.

zeroexcelcior

This is so awesome

4 hours ago Like Reply

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