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Gravity Probe B confirms Einstein effects



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Nasa's Gravity Probe B has produced remarkable new confirmation of some key predictions by Albert Einstein.

The satellite's observations show the massive body of the Earth is very subtly warping space and time, and even pulling them around with it.

Scientists were able to see these effects by studying the behaviour of four perfectly engineered spinning balls carried inside the probe.

The results are published online in the journal *Physical Review Letters*.

They are significant because they underline once again the genius of the great German-born scientist, but also because they provide more refined tools to understand the physics that drives the cosmos.

On a more human level, the findings represent the culmination of an extraordinary odyssey for the leading lights of the mission, some of whom have dedicated more than five decades to the quest.

These include Francis Everitt, the mission's principal investigator at Stanford University - a researcher who was there at the inception of the Gravity Probe B (GP-B) idea in the late 1950s.

"We've completed this landmark experiment, testing Einstein's Universe - and Einstein survives," he announced on Wednesday.

GP-B itself was not launched until 2004, and it has taken since then for the mission team to assess the data and to be sure of its observations.

Part of the group's difficulty has been in showing that some fantastically small measurements were real and not

biases introduced by flaws in the experimental set-up. For a while, it looked like the venture might not succeed.

Gravity Probe B was put in space to confirm two important consequences stemming from Einstein's Theory of General Relativity - his description of gravity. The predictions characterise the way space and time will be distorted by the presence of huge objects such as planets and stars.

One, known as the geodetic effect, is the amount by which the mass of the Earth will warp the local space-time in which it sits.

The other, which physicists refer to as frame-dragging, is the phenomenon that sees the Earth twist local space-time around with it as it rotates.

GP-B sought to observe both these effects by measuring tiny drifts in the spin axes of four gyroscopes relative to the position of a star called IM Pegasi (HR 8703).

To ensure accuracy, the balls had to be chilled to near "absolute zero" (-273C) and were flown inside a giant vacuum flask containing super-fluid helium. This and other measures isolated the spheres from any external disturbance.

If Einstein had been wrong in his ideas then the gyros should have spun unhindered by external forces (pressure, heat, magnetic field, gravity, and electrical charges).

But given the physicist has taught us that local space-time around the Earth is curved and frame-dragging then a deviation in their behaviour ought to be expected and measurable - albeit with great difficulty.

Over the course of a year, the anticipated drift in the spin axes of the balls due to the geodetic effect was calculated to reveal itself on the scale of just a few thousand milliarcseconds. The frame-dragging effect was predicted to be even smaller.

"A milliarcsecond is the width of a human hair seen at a distance of 10 miles. It really is a rather small angle, and this is the accuracy Gravity Probe B had to achieve," explained Professor Everitt.

"For the geodetic effect, the predicted relativity effect is 6,606.1 of these milliarcseconds, and the measured result is a little over a quarter of a percent of that. The frame-dragging we've measured to a little better than 20%."

Tech spin-off

The idea for the mission was first proposed in 1959, but the project had to wait until the technologies to carry it through could be invented.

"GP-B, while conceptually simple, is technologically an extremely complex experiment," said Rex Geveden, the former programme manager on GP-B and now the president of Teledyne Brown Engineering from Huntsville, Alabama.

"The idea came about three to four decades before the technology was available to test it. Thirteen novel technologies were created for GP-B. The quartz balls were thought to be the roundest objects ever manufactured. The diametric variation across the spheres is about two-tenths of a millionth of an inch."

Innovations from Gravity Probe B have fed directly into improvements in the Global Positioning System (GPS). And a Nasa mission called Cobe that pictured the Universe less than a million years after the Big Bang owed its success to technology developed on Gravity Probe B.

Unending tests

Some 100 students achieved their PhDs by working on some aspect of the mission during the many years it took to develop, build and then fly the probe.

Most of these PhDs were earned at Stanford, and at the universities in Huntsville; and in Aberdeen, UK. More than 350 undergraduate students also worked on GP-B, including one who later became the first female American astronaut in space, Sally Ride. Another was Eric Cornell, who won the Nobel Prize in Physics in 2001.

"The precession of a gyroscope in a gravitational field of a rotating body has never been measured before today. While the result in this case does support Einstein, it didn't have to," commented Professor Clifford Will from Washington University, St. Louis.

"Physicists will never cease testing their basic theories, whether in order to confirm them better or in order to reveal new physics beyond those standard theories.

"In some realms the only place to do this, to carry out such experiments, is in space. This was the case with GP-B."

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