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52 Years and $750 Million Prove Einstein Was Right

By DENNIS OVERBYE

In a tour de force of technology and just plain stubbornness spanning half a century and costing more than $750 million, a team of experimenters from Stanford University reported on Wednesday that a set of orbiting gyroscopes had detected a slight sag and an even slighter twist in space-time.

The finding confirms some of the weirdest of the many strange predictions — like black holes and the expanding universe — of Albert Einstein's theory of gravity, general relativity.

"We have completed this landmark experiment of testing Einstein's universe," Francis Everitt, leader of the project, known as Gravity Probe B, said at a news conference at NASA headquarters in Washington. "And Einstein survives."

That was hardly a surprise. Observations of planets, the Moon and particularly the shifting orbits of the Lageos research satellites had convinced astronomers and physicists that Einstein's predictions were on the mark. Nevertheless, scientists said that the Gravity Probe results would live forever in textbooks as the most direct measurements, and that it was important to keep testing theories that were thought to be correct.

Clifford M. Will of Washington University in St. Louis — who was not part of the team but was chairman of a National Aeronautics and Space Administration advisory committee evaluating its work, and who wrote a book titled "Was Einstein Right?" — said that in science, "no such book is ever closed."

Einstein's theory relates gravity to the sagging of cosmic geometry under the influence of matter and energy, the way a sleeper makes a mattress sag. One consequence is that a massive spinning object like Earth should spin up the empty space around it, the way twirling the straw in a Frappuccino sets the drink and the whole Venti-size cup spinning around with it, an effect called frame dragging. Astronomers think this effect, although minuscule for Earth, could play a role in the black hole dynamos that power quasars.

Empty space in the vicinity of Earth is indeed turning, Dr. Everitt reported at the news conference and in a paper prepared for the journal Physical Review Letters, at the leisurely rate of 37 one-thousandths of a second of arc — the equivalent of a human hair seen from 10 miles away — every year. With an uncertainty of 19 percent, that measurement was in agreement with Einstein's predictions of 39 milliarcseconds.

Likewise, the "sag" should alter the space-time geometry around Earth, warping it from the Euclidean ideal and cutting an inch out of the Gravity Probe's orbit around it, so that the circumference is slightly less than the Euclidean ideal of pi times the orbit's diameter, a fact confirmed by the Stanford gyroscopes to an accuracy of 0.3 percent.

For Dr. Everitt, who joined the Gravity Probe experiment in 1962 as a young postdoctoral fellow and has worked on nothing else since, the announcement on Wednesday capped a career-long journey.

The experiment was conceived in 1959, but the technology to make these esoteric measurements did not yet exist, which is why the experiment took so long and cost so much. The gyroscopes, for example, were made of superconducting niobium spheres, the roundest balls ever manufactured, which then had to be flown in a lead bag to isolate them from any other influences in the universe, save the subversive curvature of space-time itself.

Shortly before the probe's launching, Dr. Francis said the project had been canceled at least seven times, "depending on what you mean by canceled." It was finally sent into orbit in 2004 and operated for some 17 months, but not all went well. When the scientists began analyzing their data, they discovered that patches of electrical charge on the niobium balls had

generated extra torque on the gyroscopes, causing them to drift.

It would take five more years to understand the spurious signals and retrieve the gravity data by dint of an effort that Dr. Will called “nothing less than heroic.”

In the meantime, the NASA grant ran out. Dr. Everitt secured another one from Richard Fairbank, a financier and son of one of the experiment’s founders, William Fairbank, that was matched by NASA and Stanford. When that ran out and NASA turned him down for a new grant, Dr. Everitt obtained a $2.7 million grant from Turki al-Saud, a Stanford graduate and vice president for research institutes at the King Abdulaziz City for Science and Technology in Saudi Arabia.