Gravity Probe B confirms two Einstein theories

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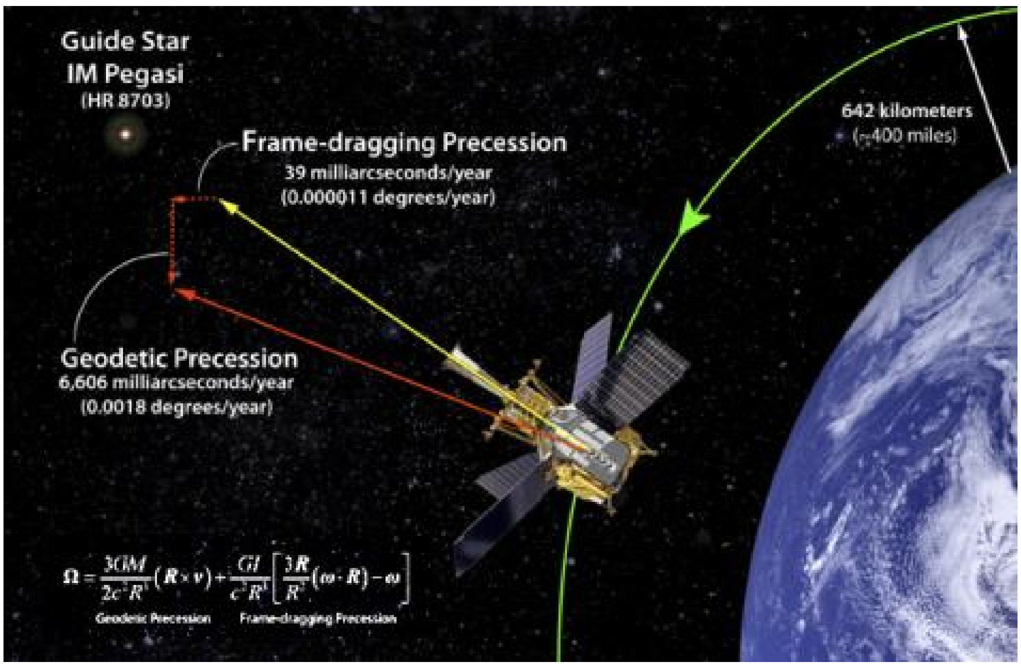

Einstein's predicted geodetic and frame- dragging effects, and the Schiff Equation for calculating them.

(PhysOrg.com) -- Stanford and NASA researchers have confirmed two predictions of Albert Einstein's general theory of relativity, concluding one of the space agency's longest-running projects.

Known as Gravity Probe B, the experiment used four ultra-precise gyroscopes housed in a satellite to measure two aspects of Einstein's theory about gravity. The first is the geodetic effect, or the warping of space and time around a gravitational body. The second is frame-dragging, which is the amount a spinning object pulls space and time with it as it rotates.

After 52 years of conceiving, building, testing and waiting, the science satellite has determined both effects with unprecedented precision by pointing at a single star, IM Pegasi, while in a polar orbit around Earth. If gravity did not affect space and time, Gravity Probe B's gyroscopes would point in the same direction forever while in orbit. But in confirmation of Einstein's general theory of relativity, the gyroscopes experienced measurable, minute changes in the direction of their spin as they were pulled by Earth's gravity.

The findings appear online in the journal Physical Review Letters.

"Imagine the Earth as if it were immersed in honey. As the planet rotated its axis and orbited the Sun, the honey around it would warp and swirl, and it's the same with space and time," said Francis Everitt, a Stanford physicist and principal investigator for Gravity Probe B.

"GP-B confirmed two of the most profound predictions of Einstein's universe, having far-reaching implications across astrophysics research," Everitt said. "Likewise, the decades of technological innovation behind the mission will have a lasting legacy on Earth and in space."

Stanford has been NASA's prime contractor for the mission and was responsible for the design and integration of the science instrument and for mission operations and data analysis.

Much of the technology needed to test Einstein's theory had not yet been invented in 1959 when Leonard Schiff, head of Stanford's physics department, and George E. Pugh of the Defense Department independently proposed to observe the precession of a gyroscope in an Earth-orbiting satellite with respect to a distant star. Toward that end, Schiff teamed up with Stanford colleagues William Fairbank and Robert Cannon and subsequently, in 1962, recruited Everitt.

NASA came on board in 1963 with the initial funding to develop a relativity gyroscope experiment. Forty-one years later, the satellite was launched into orbit about 400 miles above Earth.

The project was soon beset by problems and disappointment when an unexpected wobble in the gyroscopes changed their orientation and interfered with the data. It took years for a team of scientists to sift through the muddy data and salvage the information they needed.

Despite the setback, Gravity Probe B's decades of development led to groundbreaking technologies to control environmental disturbances on spacecraft, such as aerodynamic drag, magnetic fields and thermal variations. The mission's star tracker and gyroscopes were the most precise ever designed and produced.

Innovations enabled by GP-B have been used in the Global Positioning System, such as carrier-phase differential GPS, with its precision positioning that can allow an airplane to land unaided. Additional GP-B technologies were applied to NASA's Cosmic Background Explorer mission, which determined the universe's background radiation. That measurement is the underpinning of the "big bang theory" and led to the Nobel Prize for NASA's John Mather.

"The mission results will have a long-term impact on the work of theoretical physicists for years to come," said Bill Danchi, senior astrophysicist and program scientist at NASA Headquarters in Washington. "Every future challenge to Einstein's theories of general relativity will have to seek more precise measurements than the remarkable work GP-B accomplished."

Over the course of its mission, GP-B advanced the frontiers of knowledge and provided a practical training ground for 100 doctoral students and 15 master's degree candidates at universities across the United States. Over 350 undergraduates and more than four dozen high school students also worked on the project, alongside leading scientists and aerospace engineers from industry and government.

Sally Ride, the first American female astronaut in space, worked on GP-B while studying at Stanford. Another was Nobel Laureate Eric Cornell, who also studied at Stanford.

Provided by Stanford University

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