Stanford study backs Einstein's relativity theory

David Perlman, Chronicle Science Editor
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Stanford scientists announced Wednesday that they have confirmed two key predictions of Einstein's General Theory of Relativity, upholding the fundamental assumptions that guide today's physicists about the state of the universe.

Einstein's predictions are that the mass of all objects in space - from fleas to black holes - warps both space and time as they fall inward toward a more massive object.

And when an object spins in space and time, as Earth does, its very spinning drags both space and time along with it, the way a twirling apple inside a bowl of syrup would drag the syrup around it.

The conclusion that the revered German-born scientist was right means that today's concept of the Big Bang as the launchpad for an accelerating universe, with all its puzzling dark matter and dark energy, is also on the right cosmological track.

"The space-time around Earth appears to be distorted just as general relativity predicts," said Stanford physicist Francis Everitt, who led the large group of scientists in the $750 million NASA satellite experiment known as Gravity Probe B.

"We have completed this landmark experiment of testing Einstein's universe, and Einstein survives."

Most astronomers and physicists were already convinced that Einstein was accurate based on their own observations of objects in space.

'An epic result'

But Clifford Will, who chaired a National Research Council study that approved the project in 1998 after NASA officials sought to end it, was emphatic in his praise.

"This is an epic result," he said. "One day this will be written up in textbooks as one of the classic experiments in the history of physics."

When Albert Einstein published his general relativity theory in 1916, he considered space and time as woven together in a four-dimensional unity; physicists do so today and refer to it as "space-time."

In Einstein's theory, when gravity warps both space and time - or space-time - it's as if an object were rolling down the slopes of a stretched-out net toward another massive object in the net's center. Scientists call this warping of space-time the "geodetic effect."

Also in Einstein's theory, the drag in space-time from a spinning object is known as "frame-dragging."

To test the two key aspects of Einstein's theory, the scientists devised a set of high-precision instruments for a yearlong experiment they conducted aboard the Gravity Probe B satellite in 2004.

That experiment ended in 2005.

Crucial factor

The satellite's crucial element was a container holding four balls of pure fused quartz, each the size of a ping-pong ball, that were spun at 10,000 revolutions per minute by jets of liquid helium cooled to 450 degrees below zero.

Those tiny balls were actually gyroscopes, spinning with total regularity and precision, and were the most perfectly rounded objects ever fabricated, Everitt and his team said.

The gyroscopes, perfectly aligned, were pointed at a star named IM Pegasi, 329 light years from Earth in the constellation Pegasus.

If Einstein's theory was wrong, and gravity did not affect space and time, the gyroscopes would have pointed in the same direction forever, or as long as the satellite was sending down data from its polar orbit 400 miles above Earth.

But if the direction of the spinning gyroscopes was altered - even almost imperceptibly - by the pull of Earth's gravity, it would mean that Einstein was right. And although those changes were barely measurable by the Stanford team's most intricate instruments, that's exactly what happened, Everitt said.

Five years of data analysis by scientists at Stanford University following the Gravity Probe B experiments confirmed that Einstein's two concepts of the geodetic effect and frame dragging are correct.

"The decades of technological innovation behind the mission will have a lasting legacy on Earth and space," Everitt said.

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