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Pulsar's wobble provides new Einstein test

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Einstein can rest easy for a bit longer. Using a pair of orbiting pulsars, astronomers have confirmed a prediction of general relativity about how bodies wobble in the presence of gravity.

But in the future, the unique test will become more precise, potentially revealing deviations from the long-held theory.

Pulsars are collapsed stars made mostly of neutrons. Each spins around an axis and shines bright beams of light from its poles.

Because the stars are dense and tend to orbit any partners at close distances, strong gravitational fields are at work, making them ideal to test a number of predictions of Einstein's theory of general relativity.

Now, a team has confirmed an old prediction that the warping of space should induce a subtle wiggle in a star's spin. This "spin precession" causes its main axis to trace a circle over time, like a spinning top.

"This measurement is the first clear quantitative test of spin precession in a star or a body outside the solar system," says study author Rene Breton of McGill University in Montreal, Canada.

Lighthouse beam

Gyroscopes in Gravity Probe B, a space mission that recently earned a failing grade in a NASA review, have also showed some evidence of precession.

But the pair of pulsars in the new study, dubbed J0737-3039, shows an effect that is thousands of times more dramatic. "We're talking about a totally different gravitational regime," Breton told **New Scientist**.

Both pulsars have large magnetic fields that hold a cloud of particles in thrall.

One of the stars, "pulsar B", and its crew of particles passes in front of its companion every 2.5 hours. That blocks the light from "pulsar A", whose lighthouse-like beam happens to be pointed directly at Earth.

Full circle

By measuring the light from these eclipses, Breton and colleagues were able to use a model to infer the shape of pulsar B's magnetic field. This allowed them to find the orientation of the star's spin axis.

Over four years, the team was able to measure how much that axis changed, and found that it rotated around at a rate of a bit less than 5° a year. Over 75 years or so, the star's beacon will wobble in one full circle.

The four-year observation agrees with the prediction of general relativity to within 13%, and Breton says the measurement will become more precise the longer the pulsars are observed.

As the precision grows, the pulsar observations may reveal slight deviations from the predictions of general relativity. Some alternate theories have predicted that two bodies with identical masses but different compositions might have different gravitational effects, Breton says.

Either way, doing such a spin precession test in a strong gravitational field is good news, some say.

Pushing the limits

"Any way that we can continue to push at the limits of experimental verifications of general relativity is good because it may give us a clue as to how to unify the laws with the rest of theoretical physics," says physicist

Joseph Taylor of Princeton University in New Jersey, US, referring to the attempt to unify theories of gravity with those of quantum physics. Taylor won the Nobel Prize in 1993 for his work on binary pulsars.

J0737-3039 might be the only system that can test spin precession with eclipses. In order to do the measurements, one star's beam one needs to be shining at the Earth. The other needs to pass in front of the star in our line of sight.

"It's very unique and we really don't expect it from other systems," Breton told **New Scientist**. "I'd be better off buying a ticket for the lottery instead."

"This was completely unprecedented, we have never found any other system that had any of these eclipses," says Paulo Freire of the Arecibo Observatory in Puerto Rico, who helped identify the system.

The two pulsars are orbiting each other in a doomed embrace. That's because the stars are slowly losing energy – and inching closer together – as they emit gravitational waves. In roughly 85 million years, they will collide.

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