Einstein’s gravity theory passes extreme test, says study published in Nature

A new view of the Whirlpool Galaxy, one of the two largest and sharpest images Hubble Space Telescope has ever taken, is released by NASA on Hubble's 15th anniversary April 25, 2005. | Photo Credit: Reuters

Albert Einstein’s insights into gravity hold true even in one of the most extreme scenarios the universe can offer, according to a study.

Einstein’s understanding of gravity, as outlined in his general theory of relativity, predicts that all objects fall at the same rate, regardless of their mass or composition.

This theory has passed test after test here on Earth, but scientists have wondered whether it still holds true for some of the most massive and dense objects in the known universe, an aspect of nature known as the Strong Equivalence Principle.

The new findings, published in the journal *Nature*, show that Einstein’s insights into gravity still hold sway, even in one of the most extreme scenario.

To date, Einstein’s equations have passed all tests, from careful laboratory studies to observations of planets in our solar system.

However, alternatives to Einstein’s general theory of relativity predict that compact objects with extremely strong gravity, like neutron stars, fall a little differently than objects of lesser mass.

That difference, these alternate theories predict, would be due to a compact object’s so-called gravitational binding energy - the gravitational energy that holds it together.

Withstanding tests

In 2011, the National Science Foundation’s (NSF) Green Bank Telescope (GBT) discovered a natural laboratory to test this theory in extreme conditions: a triple star system called PSR J0337+1715, located about 4,200 light-years from Earth.

This system contains a neutron star in a 1.6-day orbit with a white dwarf star, and the pair in a 327-day orbit with another white dwarf further away.

“This is a unique star system,” said Ryan Lynch of the Green Bank Observatory in the US.

“We don’t know of any others quite like it. That makes it a one-of-a-kind laboratory for putting Einstein’s theories to the test,” he said.

Since its discovery, the triple system has been observed regularly by the GBT, the Westerbork Synthesis Radio Telescope in the Netherlands, and the NSF’s Arecibo Observatory in Puerto Rico.

If alternatives to Einstein’s picture of gravity were correct, then the neutron star and the inner white dwarf would each fall differently towards the outer white dwarf.

“The inner white dwarf is not as massive or compact as the neutron star, and thus has less gravitational binding energy,” said Scott Ransom, an astronomer with the National Radio Astronomy Observatory in the US.

Through meticulous observations and careful calculations, the researchers were able to test the system's gravity using the pulses of the neutron star alone.

They found that any acceleration difference between the neutron star and inner white dwarf is too small to detect.

"If there is a difference, it is no more than three parts in a million," said Nina Gusinskaia from the University of Amsterdam in the Netherlands.

This places severe constraints on any alternative theories to general relativity, researchers said.

The result is ten times more precise that the previous best test of gravity, making the evidence for Einstein's Strong Equivalence Principle that much stronger, they said.

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