# Gravitational constant appears universally constant, pulsar study suggests

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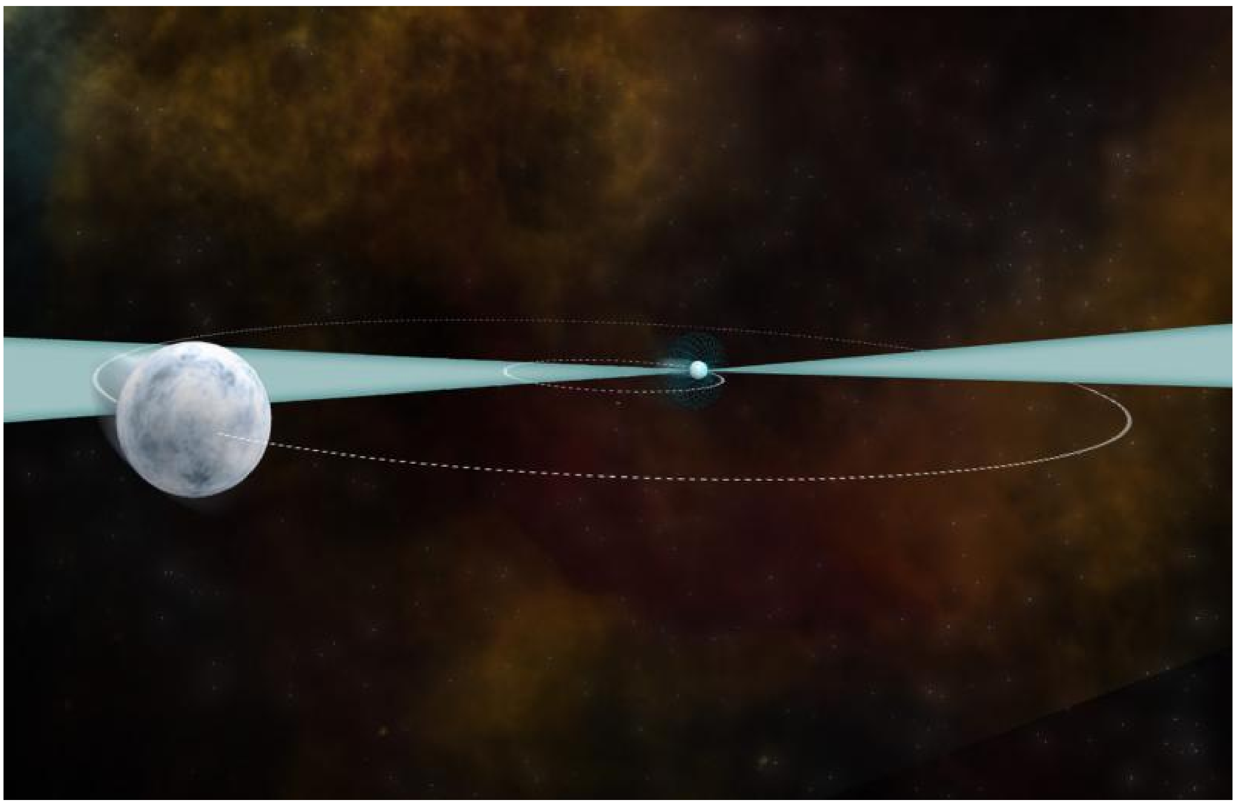

A 21-year study of a pair of ancient stars -- one a pulsar and the other a white dwarf -- helps astronomers understand how gravity works across the cosmos. The study was conducted with the NSF's Green Bank Telescope and the Arecibo Observatory. Credit: B. Saxton (NRAO/AUI/NSF)

Gravity, one of the four fundamental forces of nature, appears reassuringly constant across the Universe, according to a decades-long study of a distant pulsar. This research helps to answer a long-standing question in cosmology: Is the force of gravity the same everywhere and at all times? The answer, so far, appears to be yes.

Astronomers using the National Science Foundation's (NSF) Green Bank Telescope (GBT) in West Virginia and its Arecibo Observatory in Puerto Rico conducted a 21-year study to precisely measure the steady "tick-tick-tick" of a pulsar known as PSR J1713+0747. This painstaking research produced the best constraint ever of the gravitational constant measured outside of our Solar System.

Pulsars are the rapidly spinning, superdense remains of massive stars that detonated as supernovas. They are detected from Earth by the beams of radio waves that emanate from their magnetic poles and sweep across space as the pulsar rotates. Since they are phenomenally dense and massive, yet comparatively small – a mere 20–25 kilometers across – some pulsars are able to maintain their rate of spin with a consistency that rivals the best atomic clocks on Earth. This makes pulsars exceptional cosmic laboratories to study the fundamental nature of space, time, and gravity.

This particular pulsar is approximately 3,750 light-years from Earth. It orbits a companion white dwarf star and is one of the brightest, most stable pulsars known. Previous studies show that it takes about 68 days for the pulsar to orbit its white dwarf companion, meaning they share an uncommonly wide orbit. This separation is essential for the study of gravity because the effect of gravitational radiation – the steady conversion of orbital velocity to gravitational waves as predicted by Einstein – is incredibly small and would have negligible impact on the orbit of the pulsar. A more pronounced orbital change would confound the accuracy of the pulsar timing experiment.

"The uncanny consistency of this stellar remnant offers intriguing evidence that the fundamental force of gravity – the big 'G' of physics – remains rock-solid throughout space," said Weiwei Zhu, an astronomer formerly with the University of British Columbia in Canada and lead author on a study accepted for publication in the *Astrophysical Journal*. "This is an observation that has important implications in cosmology and some of the fundamental forces of physics."

"Gravity is the force that binds stars, planets, and galaxies together," said Scott Ransom, a co-author and astronomer with the National Radio Astronomy Observatory in Charlottesville, Va. "Though it appears on Earth to be constant and universal, there are some theories in cosmology that suggest gravity may change over time or may be different in different corners of the Universe."

The data taken throughout this experiment are consistent with an unchanging gravitational constant in a distant star system. Earlier related research in our own Solar System, which was based on precise laser ranging studies of the Earth-Moon distance, found the same consistency over time.

"These results – new and old – allow us to rule out with good confidence that there could be 'special' times or locations with different gravitational behavior," added Ingrid Stairs, a co-author from the University of British Columbia in Canada. "Theories of gravity that are different from general relativity often make such predictions, and we have put new restrictions on the parameters that describe these theories."

Zhu concluded: "The gravitational constant is a fundamental constant of physics, so it is important to test this basic assumption using objects at different places, times, and gravitational conditions. The fact that we see gravity perform the same in our Solar System as it does in a distant star system helps to confirm that the gravitational constant truly is universal."

**More information:** "Testing Theories of Gravitation Using 21-Year Timing of Pulsar Binary J1713+0747," W.W. Zhu et al. arxiv.org/abs/1504.00662

Provided by National Radio Astronomy Observatory