Gravitational waves open new chapter in long history of a spooky subject

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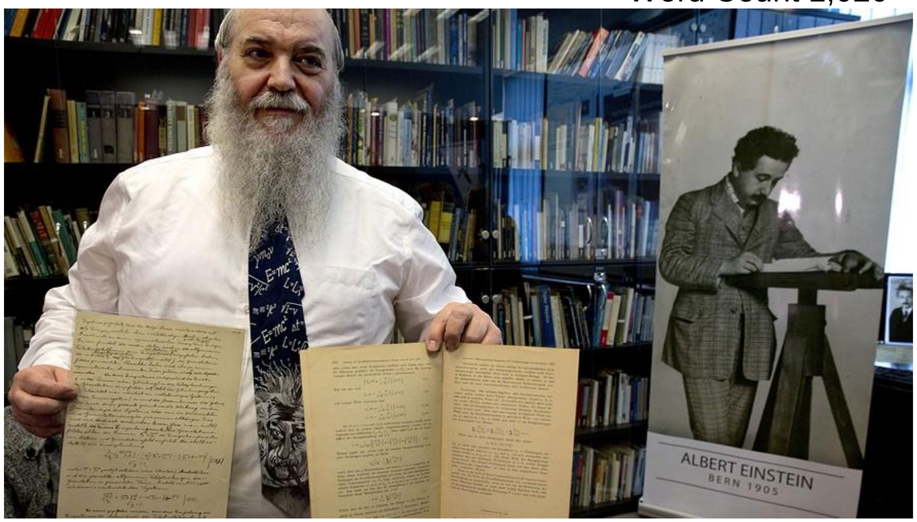

Hebrew University's Roni Gross holds the original historical documents of Albert Einstein's prediction of the existence of gravitational waves in Jerusalem, Israel, Feb. 11, 2016. In a blockbuster announcement, scientists said Thursday that after decades of trying, they have detected gravitational waves, the ripples in the fabric of space-time that Einstein predicted a century ago. Photo: AP/Sebastian Scheiner

WASHINGTON, D.C. — This has turned into Gravity Week here in Washington, D.C. Loads of journalists crammed into a news conference Thursday morning to discuss an experiment called LIGO, which stands for Laser Interferometer Gravitational-Wave Observatory.

Scientists announced that they have succeeded in detecting gravitational waves from the violent merging of two black holes in deep space. So let's mull gravity and why it's been such a mysterious force for so long.

A Little Bit Spooky

Gravity is invisible, as you may have noticed, and a little bit spooky, because it seems to reach across space to cause actions at a distance without any obvious underlying mechanism. What goes up must come down, but why that is so has never been obvious.

Physicists tell us there are four fundamental forces in the universe: Gravity, electromagnetism, the strong nuclear force and the weak nuclear force. Of these, gravity is the weakest, and yet it has shaped the universe. In our solar system, it governs the planets and moons in their orbits. On Earth, it makes apples fall from trees, and keeps humans from flying off Earth into the atmosphere.

Aristotle believed that an object fell to Earth because it sought its natural place, and that heavier objects fell faster.

Dropping The Hammer ... And The Feather

In the late 16th and early 17th centuries, Galileo discovered through scientific experiments that a heavy object and a light object actually fall at the same speed. One biographer claimed that he proved this by dropping two spheres from the Leaning Tower of Pisa, in Italy. In 1971, Apollo 15 moonwalker David Scott did his own version of the experiment, dropping a hammer and a feather and showing that they hit the moon's surface simultaneously. The moon has no air resistance to keep the feather aloft, so it fell at the same speed as the hammer.

Galileo also discovered that objects always fall with constant acceleration and along a parabolic curve. "Galileo's observation that all falling objects trace a parabola is one of the most wonderful discoveries in all of science," physicist Lee Smolin writes in his book "Time Reborn."

Newton Lays Down The Law

Then came Isaac Newton. In the second half of the 17th century, he developed a universal law of gravity. He calculated that the attraction between two bodies was equal to the product of their masses divided by the square of the distance between them. This is true on Earth as well as in space. It explains the tides in the ocean and the motions of the planets around the sun. This is a basic law of nature, true anywhere in the universe.

But even Newton admitted that he didn't understand the fundamental nature of this force. Newton could describe gravity mathematically, but he didn't know how it achieved its effects.

Einstein Throws A Curve

In the early 20th century, Albert Einstein finally came up with an explanation, and it's rather astonishing. First he grasped that gravity and acceleration are the same thing. His General Theory of Relativity, formulated in 1915, describes gravity as a consequence of the way mass curves "space time," the fabric of the universe. It's all geometry. Objects in motion will move through space and time on the path of least resistance. A planet will orbit a star because the space is warped around the star.

"Gravity, according to Einstein, is the warping of space and time," Brian Greene wrote in his book "The Elegant Universe."

The physicist John Wheeler had a famous saying: "Mass grips space by telling it how to curve, space grips mass by telling it how to move."

Looking For Elusive Waves

Einstein's great theory has been tested and retested and has always come out on top. Most famously, the British astronomer Arthur Eddington observed a solar eclipse in 1919 and concluded that starlight passing close to the sun was, indeed, bent in a manner consistent with Einstein's theory. Eddington's endorsement made Einstein a global celebrity.

One of the predictions of Einstein's equations was the existence of gravitational waves — ripples in the space time fabric. Scientists in later decades looked for such waves, but with no luck. But then the National Science Foundation chose to fund the creation of LIGO, which has two facilities, one in Livingston, Louisiana, and the other in Hanford, Washington.

LIGO had its detractors from the very start because it was going to be expensive and might detect nothing at all. These waves, if they existed, would be extremely subtle. It's not like picking up the vibration from a passing truck. The gravitational waves, in theory, should contract or expand space by only the tiniest amount. A detector a couple of miles long might become longer or shorter by less than the width of a subatomic particle.

Expensive And Complicated: Can It Work?

Gravitational waves pass through everything and can't be directly captured. So the two LIGO facilities use a laser beam to try to deduce the passing of a gravitational wave. The beam is split in two, with each part bouncing off mirrors perched at the end of perpendicular, airless tubes about 2.5 miles long. When those beams again meet, they should line up perfectly - unless some invisible gravitational waves have come rolling through the building, stretching one tube or compressing another and thereby changing the distances traveled by the beams.

One of the controversies over LIGO was simply about the name. Was it really an "observatory"? Some astronomers weren't ready to go there. Astronomy has always been a science built around light. When astronomers talk about observing with telescopes, the infrared, or with radio waves or gamma rays or X-rays, they are talking about different wavelengths of light, each creating its own visual picture of the universe.

Like Adding Sound To A Movie

But gravitational waves represent a new form of cosmic information. It is a new way of seeing the universe — or, to use a better metaphor, of hearing the universe. Physicists say this is like adding sound to what we can already see.

The movie of the universe has always been spectacular, but it is even better with sound.