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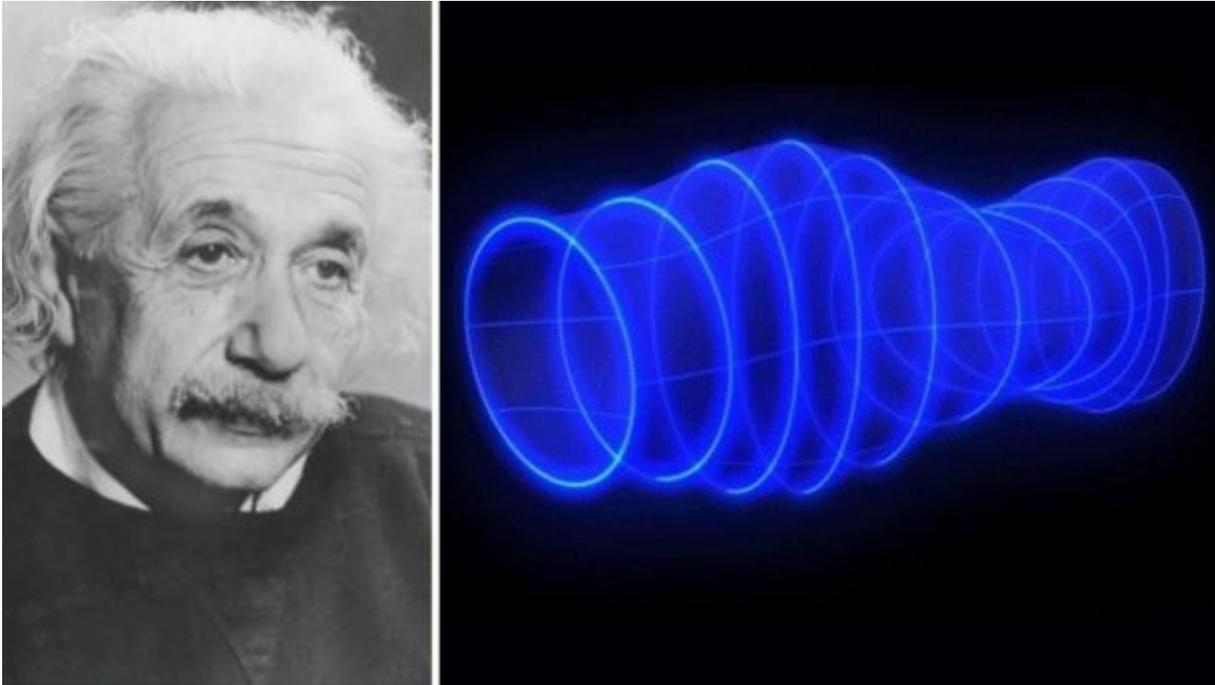
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## **Scientists find evidence of gravitational waves predicted by Einstein.**



**After decades of searching, scientists announced Thursday that they have detected gravitational waves -- essentially ripples in the fabric of space-time -- that had been predicted by Einstein.**

**An international team of astrophysicists said that they detected the waves from the distant crash of two black holes, using a \$1.1 billion instrument. The Ligo Collaboration was behind the discovery and it has been accepted for publication in the journal Physical Review Letters.**

**"We have detected gravitational waves," Caltech's David H. Reitze, executive director of the LIGO Laboratory, told journalists at a news conference in Washington, DC.**

**"Our observation of gravitational waves accomplishes an ambitious goal set out over five decades ago to directly detect this elusive phenomenon and better understand the universe, and, fittingly, fulfills Einstein's legacy on the 100th anniversary of his general theory of relativity," Reitze said in a statement.**

**The news, according to the Associated Press, is being compared by at least one theorist to Galileo taking up a telescope and looking at the planets and the biggest discovery since the discovery of the Higgs particle. It has stunned the world of physics and astronomy, prompting scientists to say it is the beginning of a new era in physics that could lead to**

scores more astrophysical discoveries and the exploration of the warped side of the universe.

**“Every year I tell my Gravity class about the three classic successes of General Relativity: the perihelion precession of Mercury, light bending and gravitational redshift. Next year, I’ll be adding a fourth: gravitational waves,” Tony Padilla, Royal Society University Research Fellow in the School of Physics & Astronomy at the University of Nottingham, said in a statement.**

**“Their detection is a stunning triumph for experiment, for theory, and most notably, for Einstein. And the source of these waves is rumored to be a merger of two black holes. Wow! Just wow! Black holes really exist," he said. "No more arguments. Looking further ahead we can look forward to a whole new era for astronomy, listening out for these remarkable signals that will teach us so much about the fundamental nature of gravity and the Universe. It’s almost as if we have grown a new set of ears, and there could be so much to hear!”**

**The discovery confirms a major prediction of Albert Einstein’s 1915 general theory of relativity. Gravitation waves carry information about their dramatic origins and about the nature of gravity that cannot be obtained from elsewhere.**

**Not only have they fascinated scientists, but found their way into pop culture -- namely through movies such as "Back to the Future," where the space-time continuum was used as a medium for the DeLorean time machine to go back in time. It also was featured in the "Terminator" series.**

**Their existence was first demonstrated in the 1970s and 1980s by Joseph Taylor, Jr., and colleagues. In 1974, Taylor and Russell Hulse discovered a binary system composed of a pulsar in orbit around a neutron star. Taylor and Joel M. Weisberg in 1982 found that the orbit of the pulsar was slowly shrinking over time because of the release of energy in the form of gravitational waves. For discovering the pulsar and showing that it would make possible this particular gravitational wave measurement, Hulse and Taylor were awarded the 1993 Nobel Prize in Physics.**

**In the latest breakthrough, the gravitational waves were detected on Sept. 14, 2015, by both of the twin Laser Interferometer Gravitational-wave Observatory (LIGO) detectors, located in Livingston, La., and Hanford, Wash.**

**Based on the observed signals, LIGO scientists estimate that the black holes for this event were about 29 and 36 times the mass of the sun, and the event took place 1.3 billion years ago. About three times the mass of the Sun was converted into gravitational waves in a fraction of a second -- with a peak power output about 50 times that of the whole visible universe.**

**By looking at the time of arrival of the signals -- the detector in Livingston recorded the event 7 milliseconds before the detector in Hanford -- scientists can say that the source was located in the Southern Hemisphere.**

According to general relativity, a pair of black holes orbiting around each other lose energy through the emission of gravitational waves, causing them to gradually approach each other over billions of years, and then much more quickly in the final minutes. In a final fraction of a second, the two black holes collide and form one massive black hole. A portion of their combined mass is converted to energy, according to Einstein's formula  $E=mc^2$ , and this energy is emitted as a final strong burst of gravitational waves.

These are the gravitational waves that LIGO observed.

“With this discovery, we humans are embarking on a marvelous new quest: the quest to explore the warped side of the universe -- objects and phenomena that are made from warped spacetime. Colliding black holes and gravitational waves are our first beautiful examples,” Caltech's Kip Thorne said.

Others, like David Clements, an astrophysicist at Imperial College London, said the discovery gives the world "a whole new tool with which to look at the universe, allowing us to look at some of the most energetic events imaginable -- collisions of black holes and neutron stars -- in ways that just were not possible before. We now have a whole new spectrum of radiation with which to study the universe.

“It's as if we were blind and today LIGO has opened our eyes,” he said in a statement.

## How Mozart Unlocked a Galactic Secret



Seeking to untangle the theory of relativity—which scientists announced confirmation of this week—Albert Einstein turned to the pure simplicity of Wolfgang Amadeus.

As he wrestled with his theory of relativity, Albert Einstein could not have imagined that the confirmation of his life's work had been vibrating ever closer through the fabric of space and time for more than 1.2 billion years.

What Einstein had understood from the start was that he would not achieve his goal of describing the essential structure of the cosmos with just conscious thought and the delineations of logic.

He instead relied upon intuition and what he described as “the architecture of music.” He would grab his violin or plunk down at the piano when he seemed stuck.

“Whenever he felt that he had come to the end of the road or into a difficult situation in his work, he would take refuge in music,” his older son, Hans, would recount. “That would usually resolve all his difficulties.”

Einstein declared that a great scientist had to be an artist before all else. He sought and found inspiration in the work of Mozart above that of all others.

“Mozart’s music is so pure that it seemed to have been ever-present in the universe, waiting to be discovered by the master,” Einstein once said.

Einstein later described Mozart’s work as “a reflection of the inner beauty of the universe itself,” adding, “like all great beauty, his music was pure simplicity.”

The biographer Walter Isaacson would quote an Einstein friend describing the great thinker as playing his violin in the kitchen late into the night. The music would suddenly stop.

“I’ve got it!” Einstein would exclaim.

He did not so much envision as intuit, feel a cosmos where space and time were a vibrant whole, expanding and shrinking, animated by gravitational waves generated by the motion of matter.

The most powerful waves he contemplated were those that would be generated by one star orbiting another. But even those waves would not be powerful enough over great distances to be measured and thereby confirmed. He himself is said to have sometimes doubted his conjectures.

In 1952, the Juilliard String Quartet gave Einstein a private concert at his Princeton, New Jersey home. The man who could intuit across vast reaches of space and time was now 72 and as subject as anybody else to aging as calibrated by the human life span. He initially declined when the quartet asked him to join them, explaining that a decline in manual dexterity had led him to give away his violin.

The quartet had a spare and asked Einstein what he wanted to play. Einstein agreed and chose a Mozart quintet.

**“Dr. Einstein hardly referred to the notes on the musical score,” the first violinist, Robert Mann, would later say, as reported by The New York Times. “While his out-of-practice hands were fragile, his coordination, sense of pitch, and concentration were awesome.”**

**Einstein died three years later, his theory still unproven. Those who felt about him much the way he had felt about Mozart included Joseph Weber, a physicist at the University of Maryland. Weber set to making a device that he hoped would prove able to detect gravitational waves.**

**In 1969, Weber announced that he had succeeded. But other scientists were unable to reproduce his results and decided that what Weber had declared to be confirmation of Einstein’s theory was in fact just background noise. Weber was still passionately defending his work when he died in 2002.**

**Others had begun their own efforts, notably Rainer Weiss of MIT. He conducted a study of the sources of such background noises. His research then turned to ways to dampen them.**

**Weiss teamed up with two Caltech scientists, Kip Torne and Ronald Drever. The physicists were somehow able to convince the government to invest many, many millions of dollars constructing two Laser Interferometer Gravitational-Wave Observatories (LIGOs), one in Louisiana, the other in Washington state.**

**Construction began in 1994 and the LIGOs were operational in 2001. Long years of refining and waiting ensued. Tension among some participants prompted one wag to suggest that Caltech should put “Prozac in the water coolers.”**

**Thorne became the best known of the team, acting as a consultant for the time-travel movie “Interstellar.” Drever is said to have been the most creative and if he acquired a reputation for being difficult, it was in the way of Mozart.**

**“It’s going to happen sometime,” he was quoted saying of the effort. “One mustn’t die before then.”**

**In another cruelty of the human lifespan, Drever is said to have developed dementia and to have been consigned to an extended care facility in Scotland. He was cheated out of being able to join the excitement when the automatic sensors of the LIGOs picked up a particular signal early on the morning of Sept. 14 of last year.**

**Just three days before, the scientist had considered shutting down the LIGOs to make some adjustments. They then decided to maintain the vigil uninterrupted. Had they not, they all would have missed by three days something that had been on the way for 1.3 billion years.**

**The researchers spent the next four months confirming that the signal was indeed what they hoped. They deduced that two black holes had circled each other and then united, generating a more massive gravitational wave than Einstein ever imagined.**

**On and on and on, the wave had rippled through the fabric of space and time, approaching ever closer as Mozart composed his music and Einstein composed his theories.**

**When the wave finally reached Earth, it was still strong enough to ever so slightly, but oh so unmistakably, alter mass and time just as Einstein figured. And the LIGOs were able to make an audio recording that established what Mozart had already proven; the cosmos are more fully heard than seen; sound tells you more than sight; the listener, not the beholder, is supreme.**

**The confirmation that time is indeed relative brings hope that time travel might eventually become more than just the stuff of movies. You can fantasize visiting Mozart and Einstein as well as Weber and, of course, poor Drever at his sharpest.**

**Imagine how thrilled they would all be to learn that the confirmation of Einstein's theory as inspired by Mozart had arrived here as a note in middle C.**