FURTHER REVIEW

The tremendously powerful collision of two black holes is seen in this computer simulation. It was an event like this, 1.3 billion years ago, that LIGO detected 10 years ago.

THE SXS PROJECT

WAVING AT THE UNIVERSE

By Charles Apple | THE SPOKESMAN-REVIEW

Albert Einstein, in his general theory of relativity published in 1916, suggested the possibility of waves of gravity in space and time.

These waves could be caused by gigantic events like the collision of black holes. They'd then travel throughout the universe at the speed of light.

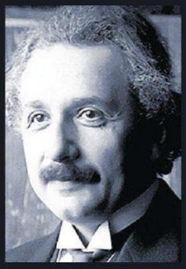
It took 101 years for Einstein's theory to be proven correct. On Sept. 14, 2015 — 10 years ago today — the first gravitational waves were discovered by two enormous detection arrays.

One of those detectors was in Hanford, Washington.

THE SEARCH FOR WAVES THAT MIGHT OR MIGHT NOT EXIST

There were so many revolutionary ideas hidden within — or just suggested by — Albert Einstein's theory of relativity that even *he* had trouble getting his head around some of them.

Einstein reportedly had trouble believing black holes and gravitational waves were real. By 1936, he became frustrated when his every attempt resulted in quantities that became infinite. Einstein gave a talk and published a paper that year entitled "The Nonexistence of Gravitational Waves."



Albert Einstein

But some of his colleagues and rivals weren't so sure. Work researching what might be the nature of gravitational waves and how they might be detected went on during the 1940s and 1950s. An important landmark along the way was a conference on gravity and general relativity at the University of North Carolina in 1957.

That conference resulted in physicists building detectors that might find evidence of gravitational waves. One scientist claimed to have found them in 1969, but number crunchers proved his conclusions were wrong.

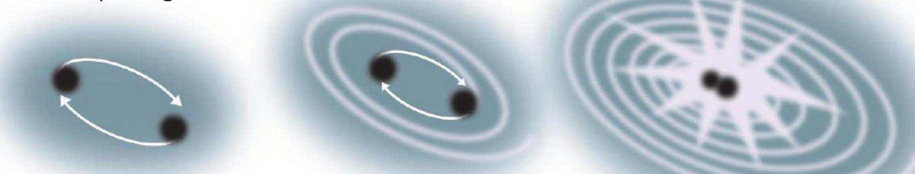
That wrong turn inspired Rainer Weiss of MIT, in 1972, to develop a device that might be able to detect gravitational waves. His ideas had merit. What his invention needed was scale: It needed to be much, much larger.

He and colleagues from Caltech began to push for an interferometer. Funding was granted in 1979, canceled and then funded again in the mid-1990s. What they called the Laser Interferometer Gravitational Wave Observatory — including two 2.5-mile-long underground tubes — was built at the old nuclear reactor site at Hanford, Washington. Another LIGO was built 2,000 miles away near Baton Rouge, Louisiana.

The LIGO arrays began operating in 2000 and were expected to begin collecting data on Sept. 18, 2015. But once again, Einstein's gravitational waves found a way to confound the science world when scientists in Louisiana and Washington indicated they had indeed found a gravitational wave, generated 1.3 billion light years away.

WHAT CREATED THE GRAVITATIONAL WAVES

Black holes are the remnants of collapsed giant stars.

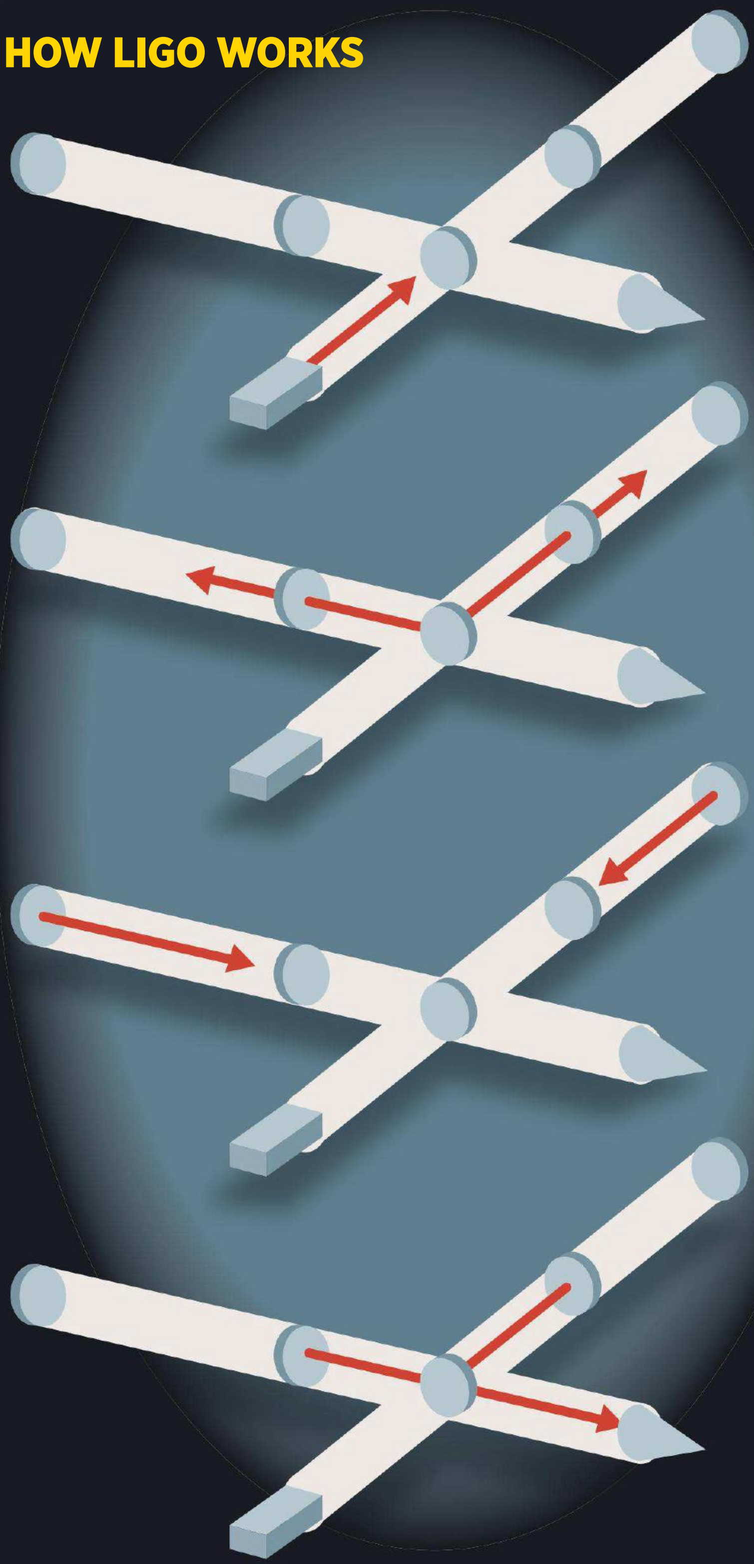


As two black holes come close, they begin to orbit each other. This might go on for millions of years before significant ripples are created.

As the holes come closer, they create ripples in the form of gravitational waves. Those waves spread into the surrounding space-time, releasing energy and allowing the holes to orbit closer and faster.

The inevitable collision of the black holes releases massive shock waves into space-time — waves moving at the speed of light.

HOW LIGO WORKS



1 Scientists send laser light into the LIGO array.

2 A beam splitter splits the light into two identical beams of light that travel down the 2.5-mile-long arms.

3 The beams reflect off the mirrors at the ends of the arms and return.

A gravitational wave passing through the detector would affect the two arms differently, causing one to expand and the other to contract.

4 The light is directed into a detector.

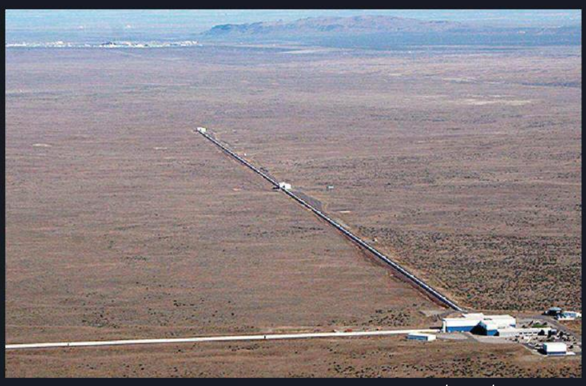
If there is *no* gravitational wave, there is no reading.

If there *is* a gravitational wave, the two beams produce a result that shows interference because they have traveled different distances.

SEPT. 14, 2015: SUCCESS AT LAST

The gravitational wave passed the Louisiana LIGO array at 4:40 a.m. Central Time that morning. It passed through the Hanford center 7 milliseconds later. The wave — really, a minute tremble — was 10,000 times smaller than the nucleus of an atom.

The signals were nearly identical. It turned out to be the proof for which scientists had been searching for more than a century.

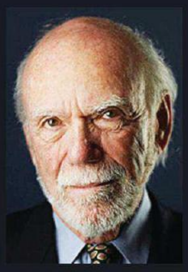


CALTECH/MIT/LIGO LAB

The Hanford LIGO detector

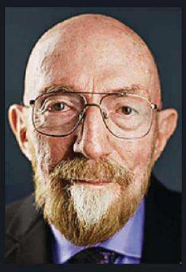
More than 1,000 researchers from more than 20 countries had been involved in developing and building the Laser Interferometer Gravitational-Wave Observatory.

In 2017, three scientists — Barish, the leader of the LIGO project, along with research pioneers Rainer Weiss and Kip Thorne — were awarded the Nobel Prize in Physics "for decisive contributions to the LIGO detector and the observation of gravitational waves."



Barry C. Barish
Professor of Physics, Caltech, Pasadena, Calif.

Rainer Weiss
Professor of Physics, MIT, Cambridge, Mass.



Kip S. Thorne
Professor of Physics, Caltech, Pasadena, Calif.

Sources: "Einstein's Monsters: The Life and Times of Black Holes" by Chris Impey, "Quantum Physics" by Rebecca Mileham, "How Space Works: The Facts Visually Explained" by Dorling Kindersley, "The Infographic Guide to Science" by Tom Cabot, "The Road to Relativity: The History and Meaning of Einstein's 'The Foundation of General Relativity'" by Hanoch Gutfreund and Jürgen Renn, the Royal Swedish Academy of Sciences, the Nobel Prize Organization, the LIGO Laboratory at CalTech

PHOTOS OF NOBEL PRIZE WINNERS FROM NOBEL PRIZE OUTREACH. PHOTO OF ALBERT EINSTEIN FROM WIKIMEDIA COMMONS.