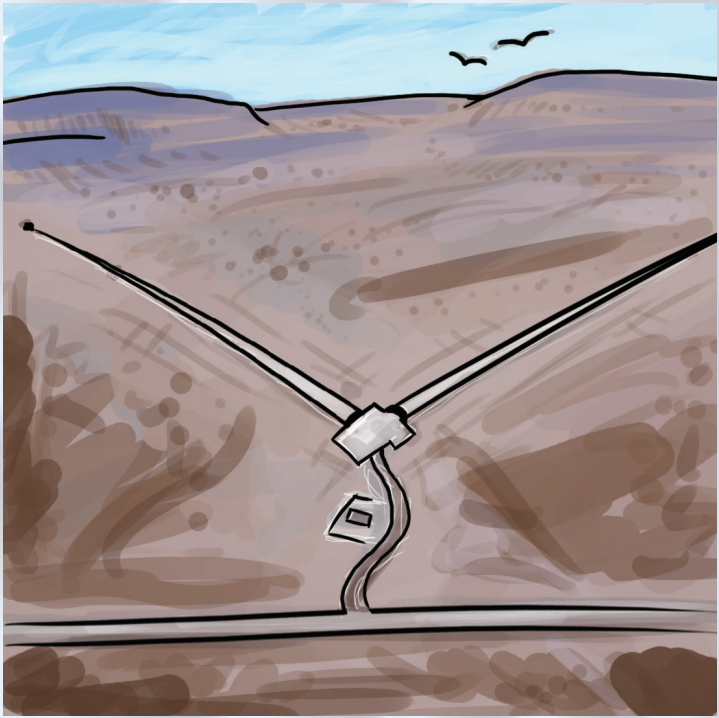
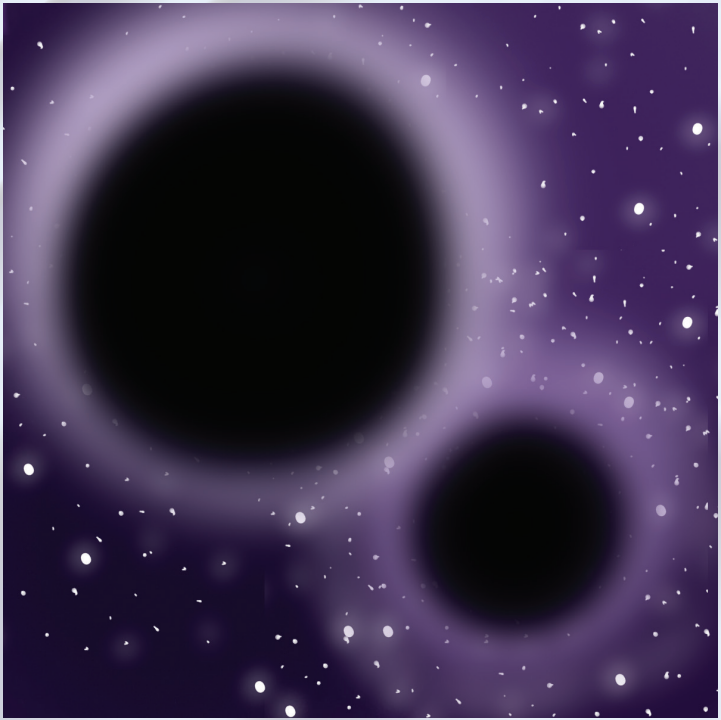
The ABCs of LEGO

is for Advanced LIGO the world's most sensitive instrument



Advanced LIGO is a pair of exceptionally sensitive interferometers tasked with detecting gravitational waves from large cosmic events.

is for Binary Black Holes that had a colliding incident

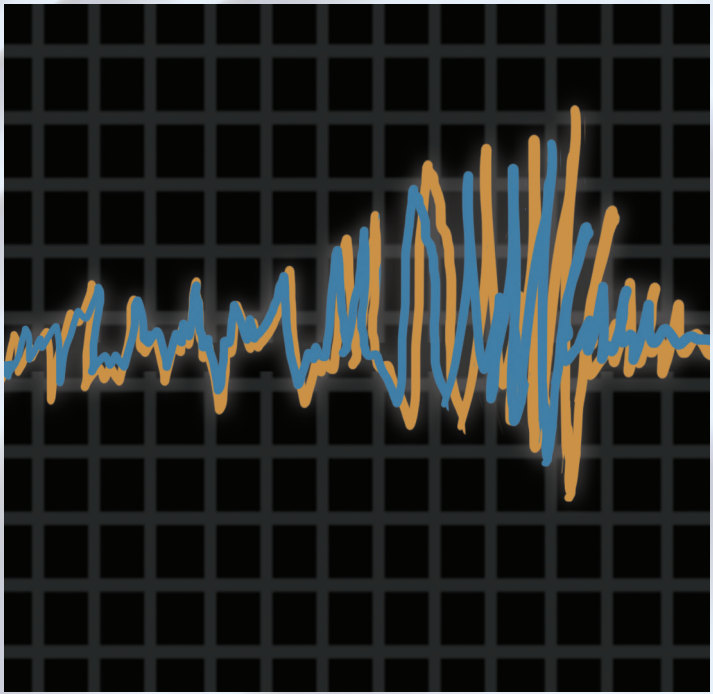


Binary black holes orbit each other and eventually merge. LIGO's initial detections have confirmed the existence of binary black holes.

is for Collaboration
1000 scientists strong

Collaboration is fundamental in science. The LIGO observatories are just a small part of the LIGO Scientific Collaboration which consists of over 1000 scientists from over 100 institutions in 18 different countries.

is for the Detection that everyone was waiting on

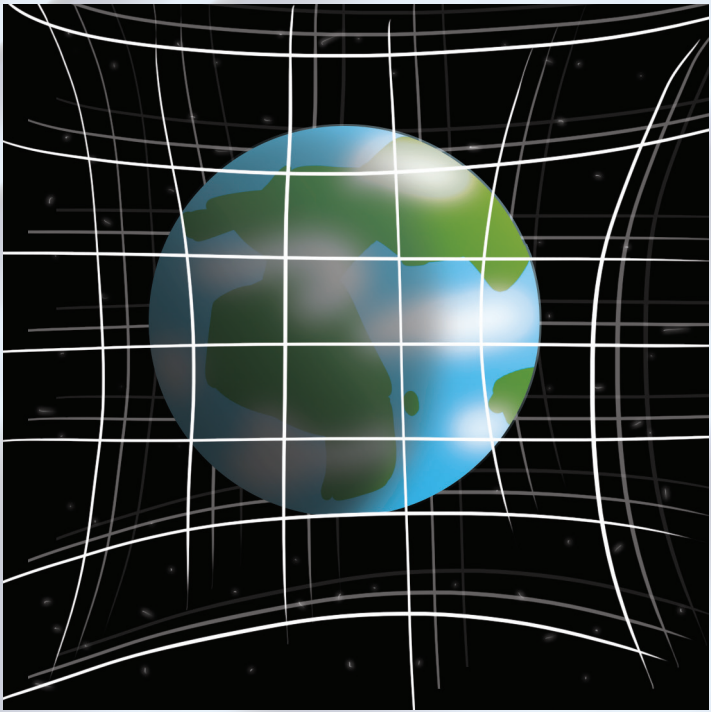


The first detection of gravitational waves came on September 14, 2015. A gravitational wave produced by the merging of two black holes traveled through the universe for over a billion years. It took only 7 milliseconds for it to travel between the Hanford and Livingston interferometers.

is for Einstein whose prediction we confirmed

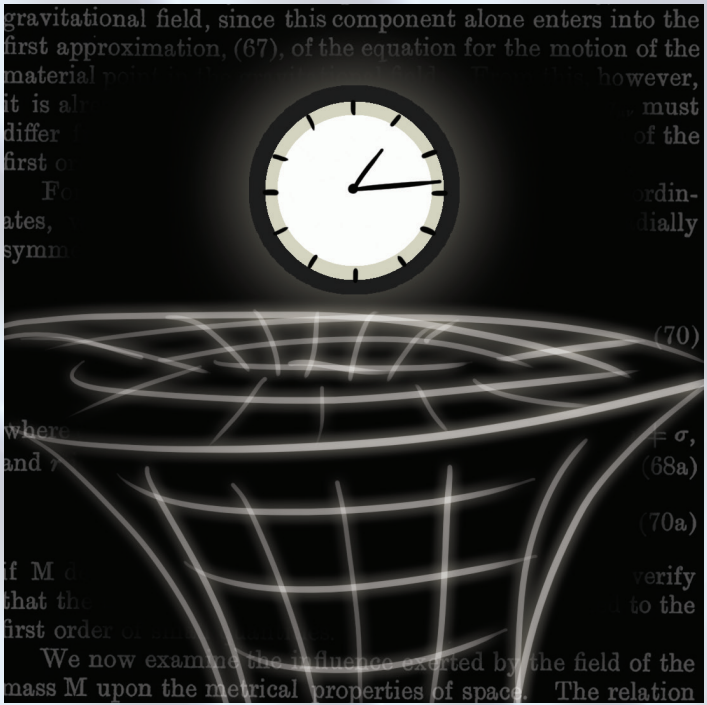
In 1915 Einstein produced his General Theory of Relativity. Gravitational waves were one of the predictions that came out of General Relativity.

is for Fabric of space-time which is warped, so we've learned



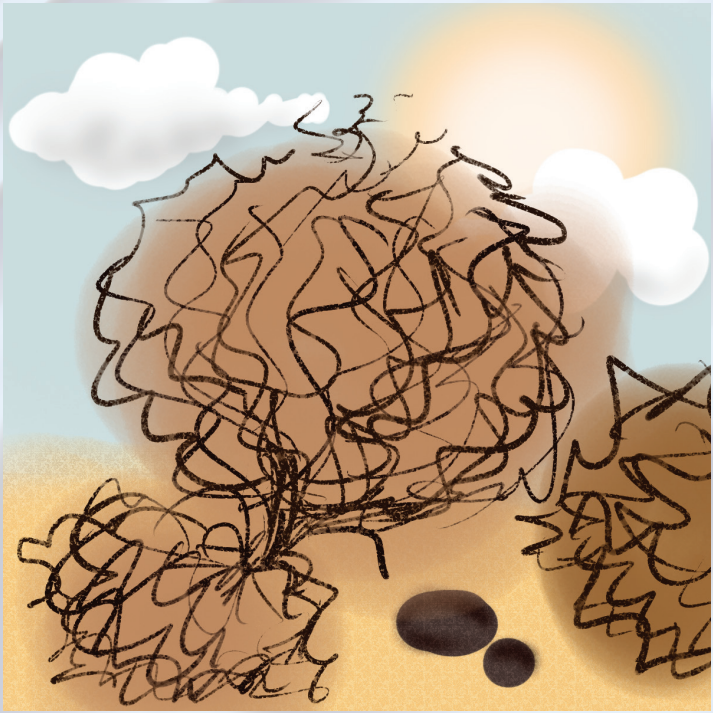
Einstein showed that space and time were not two separate entities, but are interwoven like a fabric. The fabric of space-time is warped by objects with mass and the warped fabric makes objects move.

is for General Relativity one of its last predictions finally shown



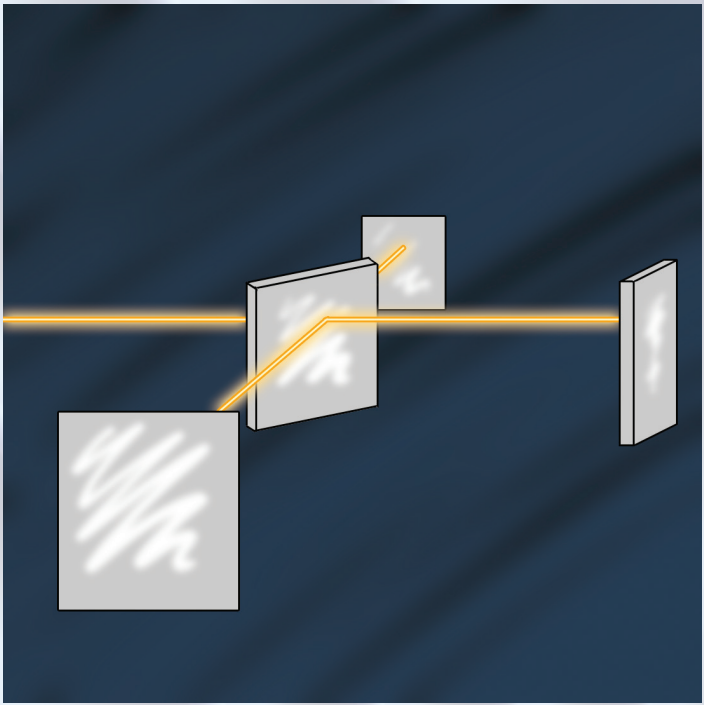
Einstein's General Relativity made many predictions including time dilation, bending of light and gravitational waves. Gravitational waves are among the last of the predictions to be verified. While there was indirect evidence for gravitational waves, LIGO made the first direct detection.

H is for Hanford where the tumbleweeds make us groan



LIGO's Hanford Observatory is just outside Richland, Washington. Hanford's beautiful shrub steppe produces thousands of tumbleweeds each year!

is for Interference pattern that shifts with a wave

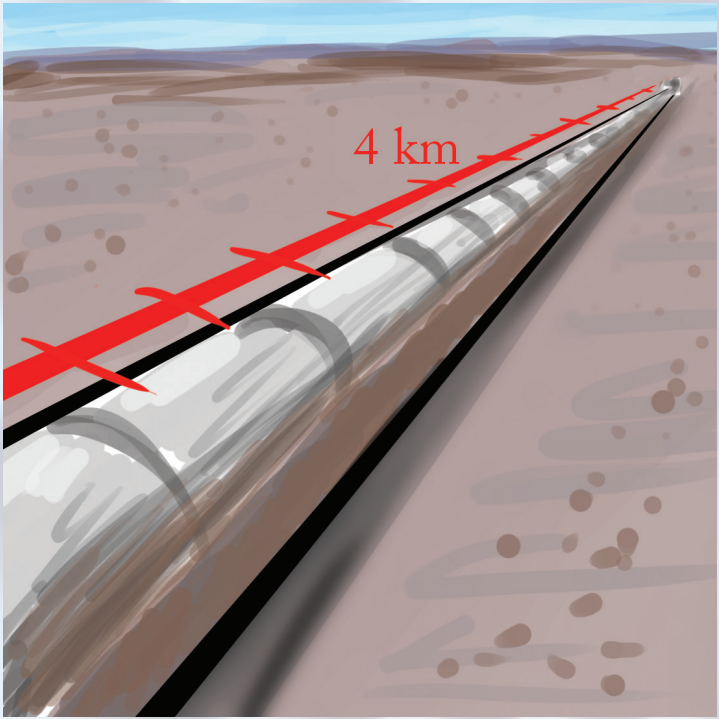


At the heart of LIGO's detectors is interference between the laser light that returns from each arm. Without a passing wave, the light signals cancel each other out. As a gravitational wave passes, the interference pattern shifts, signaling changes in the lengths of the arms.

is for Joseph Weber whose claims sent a shockwave

Joseph Weber was the first scientist to try to detect gravitational waves using metal cylinders ("Weber bars"). He claimed to have detected gravitational waves, but these claims were later disproven. Still his early work inspired many scientists to search for gravitational waves.

is for kilometers, the
length unit of each arm

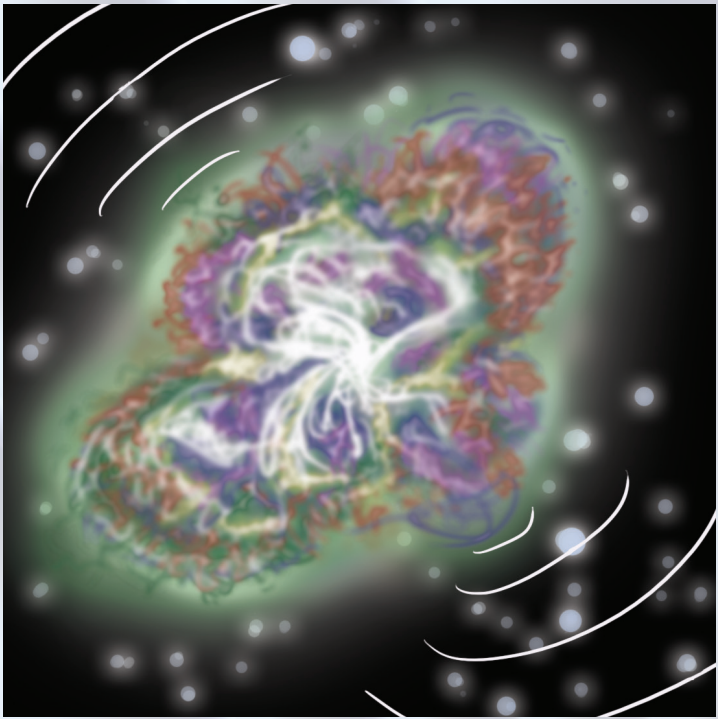


Each of LIGO's arms are 4 kilometers (2.5 miles) long.

is for Livingston where the alligators are part of the charm

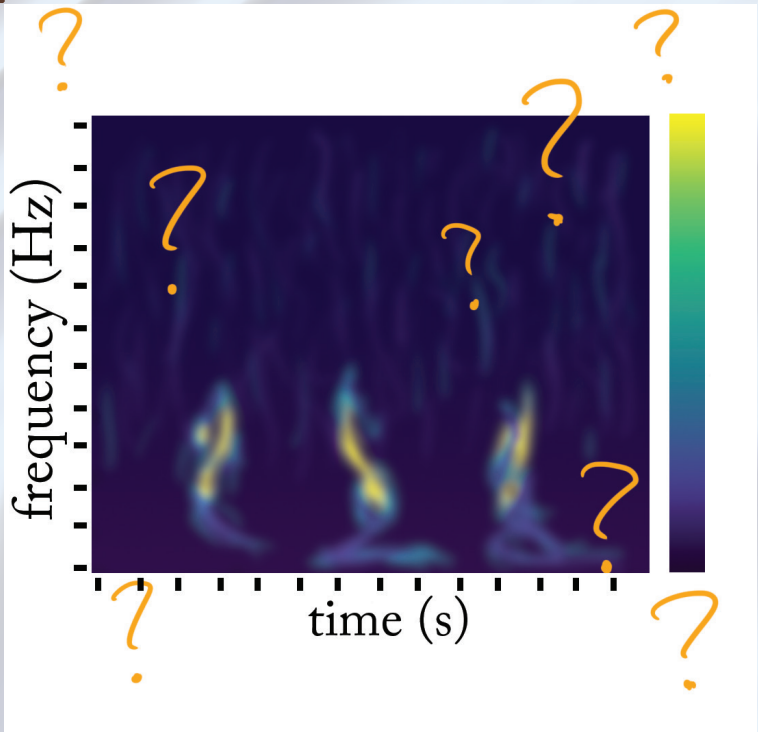
Livingston is Hanford's twin observatory, located just outside of Baton Rouge, Louisiana. Alligators are periodically spotted nearby.

is for Multimessenger astronomy whose time is here



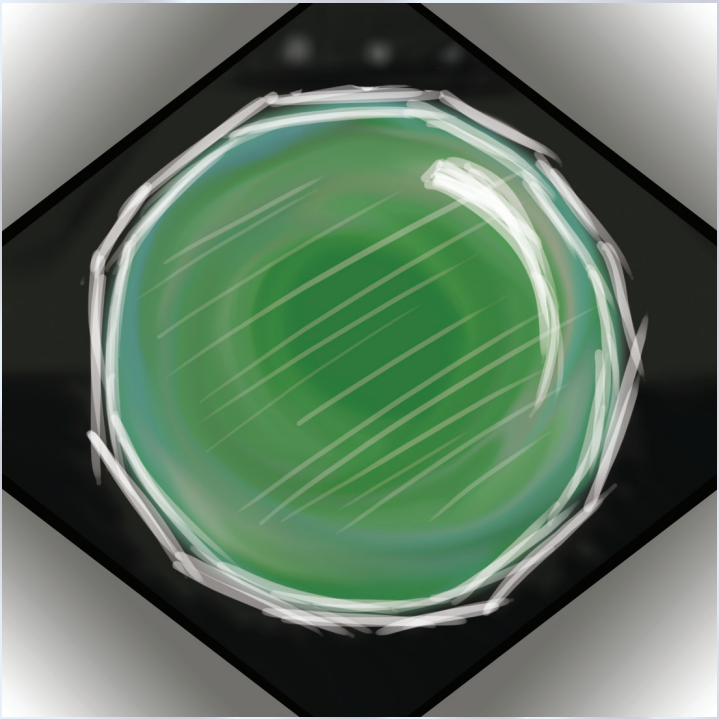
Multimessenger astronomy describes the many ways that scientists now study the Universe. Beyond electromagnetic radiation, there are gravitational waves, cosmic rays and neutrino detections.

is for Noise: it's hard work to make it disappear



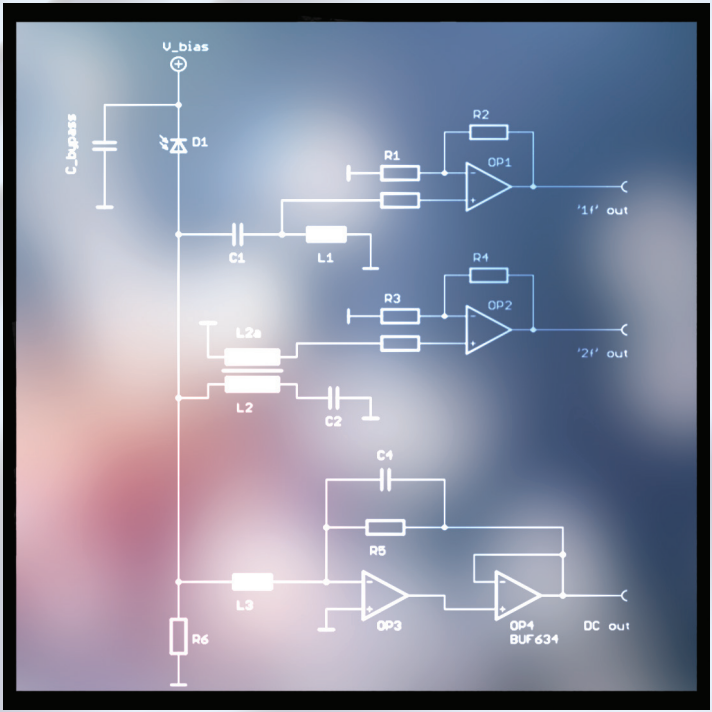
Noise is the name given to any unwanted signals in our detectors. LIGO scientists work very hard to remove as many sources of noise as possible to increase the sensitivity of the interferometer.

is for Optics, the purest you will find



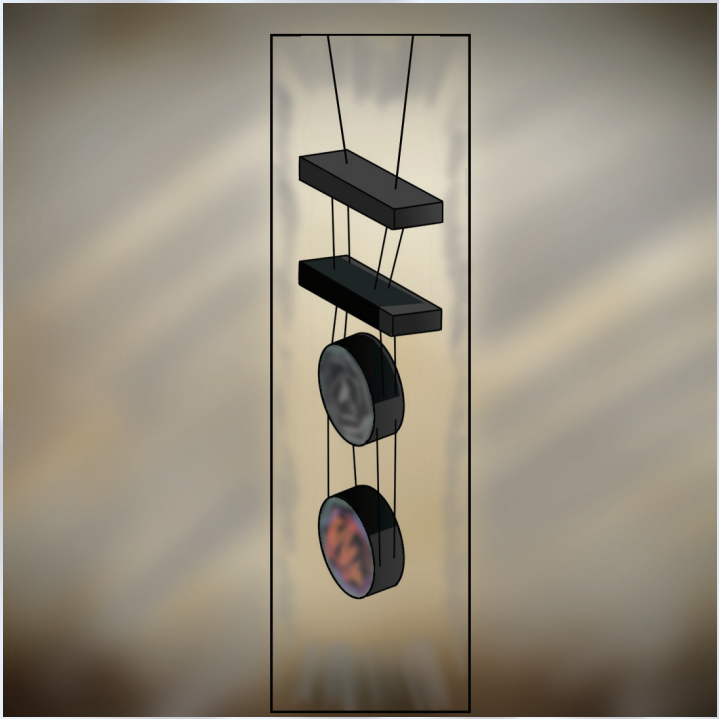
Optics are found throughout LIGO's interferometer. For example, at the end of each arm, a 40 kg (88lb) ultra-pure fused silica mirror reflects the laser light back down the arm.

is for Photodetector
without which we'd be blind



The photodetector senses the amount of light returning from the interferometer arms. As a gravitational wave passes, the amount of light the detector receives varies.

is for Quadruple pendulum at the bottom of which mirrors rest

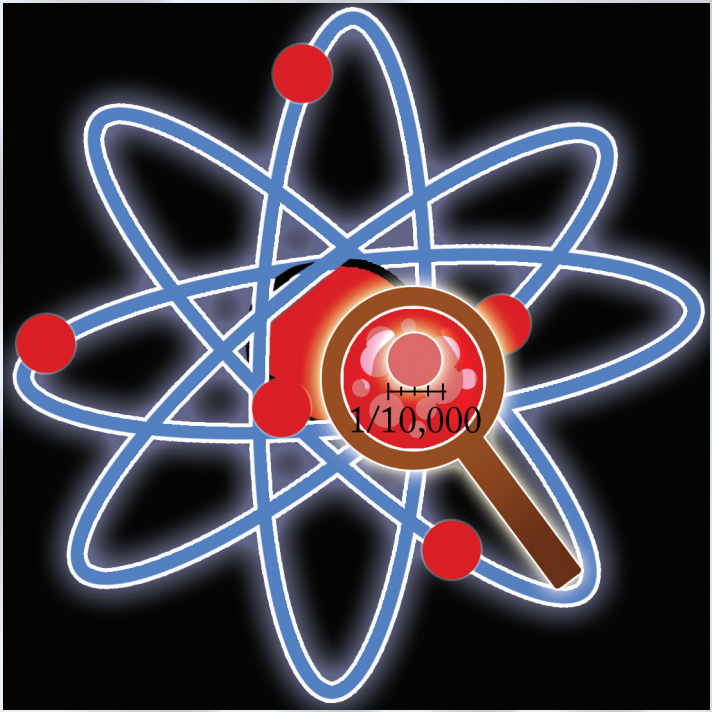


LIGO's mirrors are located at the bottom of four stages of a pendulum. This quadruple pendulum system greatly reduces the movement of the mirrors.

is for Rainer Weiss a beloved founding father whose ideas are the best

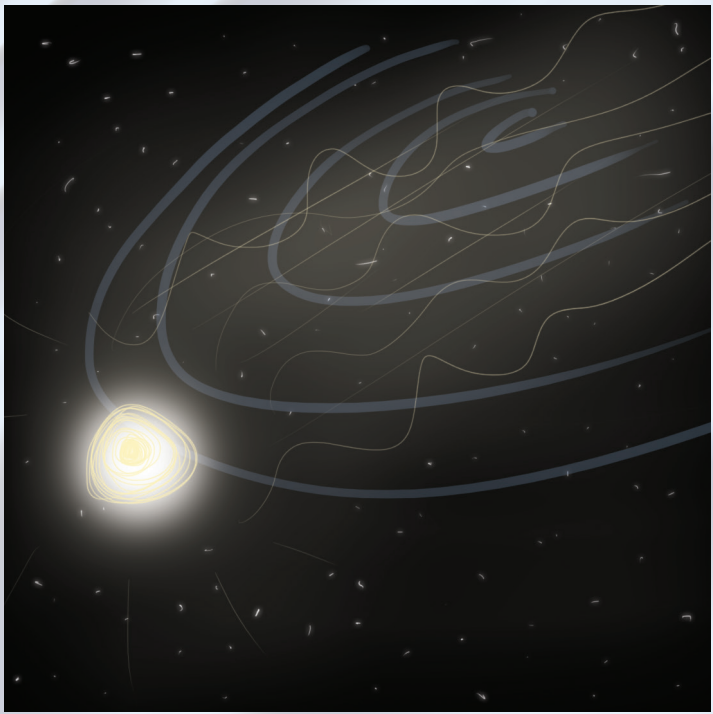
While it took many people to build Advance LIGO, the beginnings of LIGO can be found in a 1972 MIT internal paper authored by Rainer Weiss describing a kilometer long interferometer.

is for Sensitivity 1/10,000th the diameter of a proton



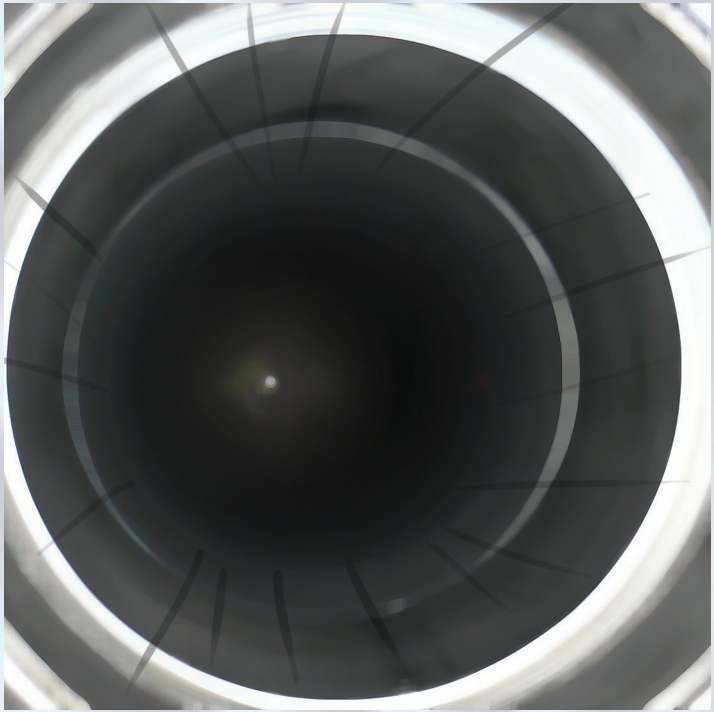
Gravitational waves are so small that Einstein thought it would be impossible to ever measure them. LIGO's extreme sensitivity enables the detection of these tiny gravitational waves.

T is for Travel Time, 1.3 billion years at the speed of a photon



Gravitational waves travel at the speed of light. LIGO's first detection on September 14, 2015 traveled across the universe for 1.3 billion years before reaching our detectors.

is for Ultra high vacuum as low as one trillionth of an atmosphere

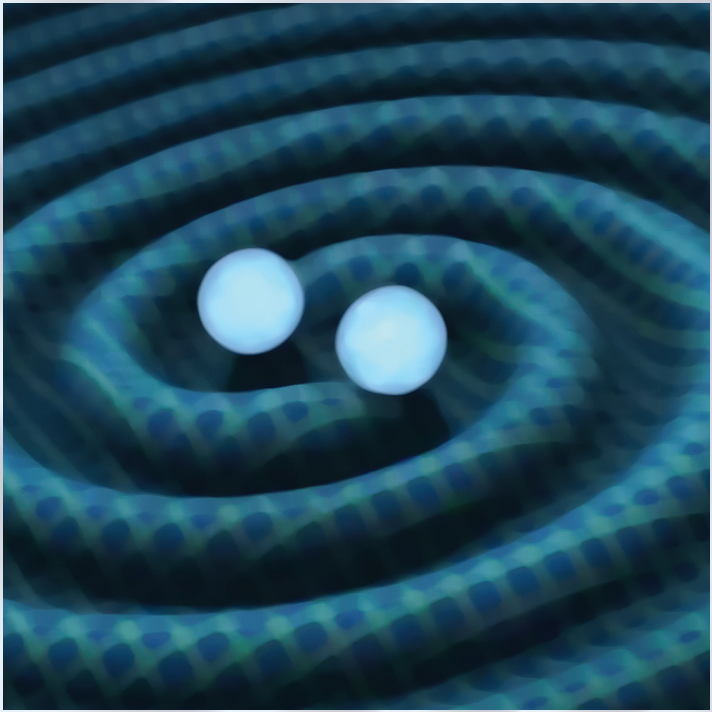


LIGO's needs ultra-high (10^{-9} torr) vacuum to operate. To achieve this vacuum 10,000 cubic meters (353,000 cubic feet) of air were pumped out.

is for Vibration isolation so important it is clear

The extreme sensitivity needed to measure gravitational waves means that any vibrations from distant earthquakes to nearby logging trucks can create noise in the instrument.

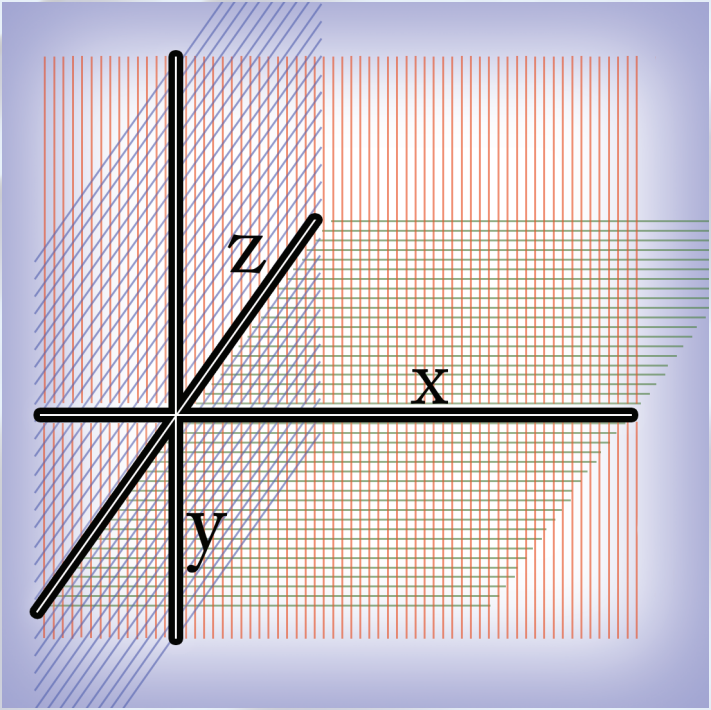
is for the Waves that grab LIGO's attention



Waves of two types are central to LIGO. LIGO utilizes interference (the wave behavior of light) to measure passing gravitational waves (ripples in the fabric of spacetime).

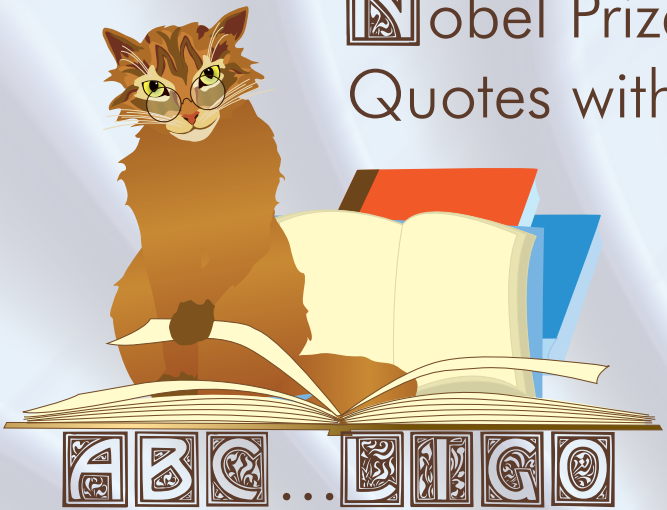
XYZ

one for each
spatial dimension



Cartesian coordinates label the three spatial dimensions as x, y and z. The arms of LIGO's interferometer are called X-arm and Y-arm.

Nobel Prize Winner Quotes with Ogil!



You can't do science and move forward without taking risks.
Kip Thorne

The most exciting science requires the most complex instruments.
Barry Barish

One of the things I sort of dreamt about awhile ago is that if Einstein were still alive, it would be asboslutely wonderful to go tell him about the discovery, and he would have been very pleased, I'm sure of that.
Rainer Weiss

I think that the future of the human race is to spread through the universe, and now is the time that we should be laying the foundations for that.
Kip Thorne

You think Earth's gravity is really something when you're climbing the stairs. But, as far as physics goes, it is a pipsqueak, infinitesimal, tiny little effect.
Rainer Weiss

When I was really young, my ambition wasn't to do science. I didn't really know that I could. It was to write a great novel.
Barry Barish

About LIGO

The Laser Interferometer Gravitational Wave Observatory (LIGO) is comprised of two detectors located near Richland, WA and Livingston, LA. These detectors are tasked with detecting gravitational waves. LIGO works with other detectors including Virgo in Italy and GEO600 in Germany. They will soon be joined by KAGRA in Japan and LIGO India. LIGO is funded by the National Science Foundation and operated by Caltech and MIT.

About OGIL

Meet Ogil, LIGO's mascot. Ogil is a curious cat who enjoys learning about space and sharing his knowledge with kids.

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Illustrations and Layout: Bella Lopez, Hannah Preisinger & Aurore Simonnet
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For more information see:
ligo.org
ligo.caltech.edu

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