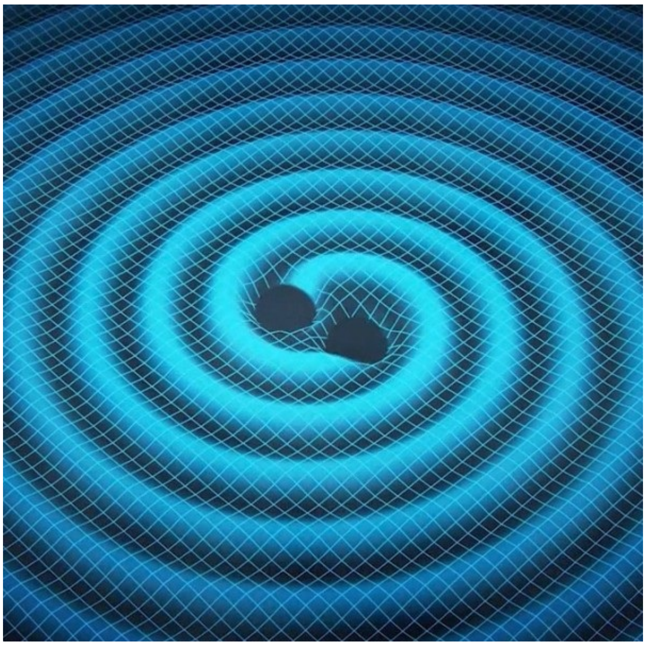
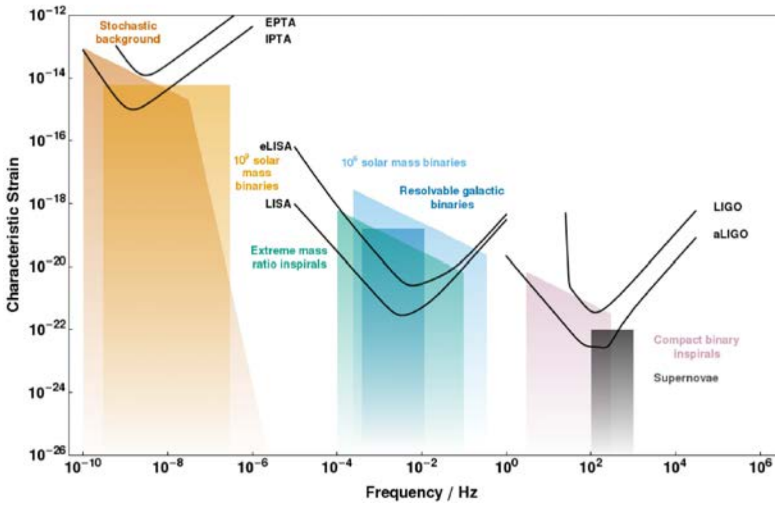
GRAVITATIONAL WAVES DETECTED!



We can now detect gravitational waves, says LIGO and unanticipated discoveries and unexpected marvels lie ahead. Gravitational waves are created by any relative changes in the matter / mass arrangement in space, including (of course) some of the most violent events in our universe, such as the merger of two black holes.

Predicted by Einstein as part of his Theory of General Relativity 100 years ago, it appears scientists have finally been able to detect these mysterious ripples in spacetime. **David Reitze**, executive director of the LIGO Laboratory at Caltech, compared the newly acquired ability to detect these elusive waves to **Galileo's** first use of a telescope 400 years ago. **Few doubt that this discovery will be worth a Nobel Prize. It will let us explore the universe in a whole new way.**

While all mass disturbances create Gravitational Waves, it takes particularly violent events such as supernovae, collisions of neutron stars and mergers of black holes to make them detectable with today's technology. **By the time these waves reach Earth, the ripples are on the order of a billionth the diameter of an atom, and thus scientists have had to be exceedingly clever to find ways to detect these elusive ripples.**



LIGO – which stands for Laser Interferometer Gravitational-Wave Observatory – originally went online in 2002 and ran until 2010 and found zero gravitational waves. That's not surprising because the frequency of these waves coming to Earth from a given volume of space – the volume of space accessible by LIGO in its first run – was predicted to be exceedingly rare. That's why LIGO upgraded its instrumentation, increasing its sensitivity by 10 times. Advanced LIGO can now detect gravitational waves from a volume of space 1,000 greater than before, and thus the upgrade gives ALIGO much more chance of spotting gravitational waves. At Advanced LIGO's current level of sensitivity, we should be seeing several of gravitational wave events per year.

Why is finding gravitational waves such a great deal, a monumental scientific discovery? Because being able to detect gravitational waves opens a new window on the universe. It will allow us to see the universe in a whole new way. Using gravitational waves, scientists can study black holes, neutron stars and the early universe as never before, and, for sure, that ability will lead to unanticipated discoveries, unexpected marvels.

It confirms the last big prediction of Einstein's theory of general relativity, a theory so incredibly innovative and unique when he first published it, and which still drives much of our current cosmology, our picture of the universe as a whole.

LIGO is the largest and most ambitious project ever funded by the National Science Foundation (NSF) with important contributions from the UK Science and Technology Facilities Council, the Max Planck Society of Germany, and the Australian Research Council. and is organised by the LIGO Scientific Collaboration which includes more than 900 scientists worldwide.

HISTORY

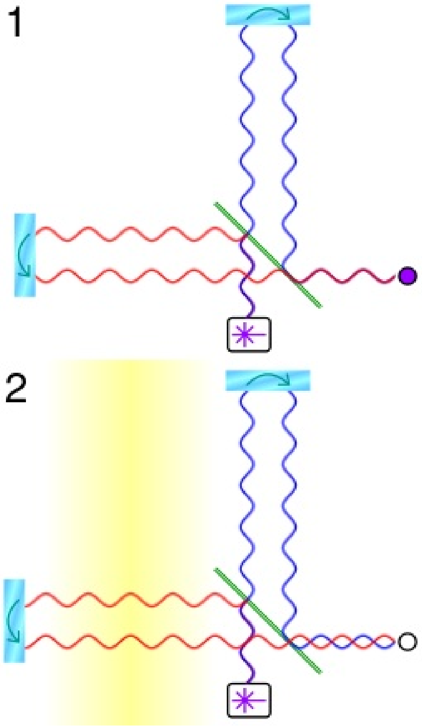
The LIGO concept built upon early work by many scientists, starting in the 1960s, American scientists including **Joseph Weber**, as well as Soviet scientists **Getsenshtein and Pustovoit**, conceived of basic ideas and prototypes of laser interferometry. In 1968, **Kip Thorne** initiated theoretical efforts on gravitational waves and their sources at Caltech, and was convinced that gravitational wave detection would eventually succeed. In 1980, the NSF funded the study of a large interferometer and the following year, Caltech constructed a 40-metre prototype. The MIT study established the feasibility of interferometers at a 1-kilometre scale with adequate sensitivity.

In 1994, with a budget of USD 395 million, LIGO stood as the largest overall funded NSF project in history. The project broke ground in Hanford, Washington in late 1994 and in Livingston, Louisiana in 1995. Initial LIGO operations between 2002 and 2010 did not detect any gravitational waves. In 2004, the funding and groundwork were laid for the next phase of LIGO development (called "Enhanced LIGO"). This was followed by a multi-year shut-down while the detectors were replaced by much improved "Advanced LIGO" versions. Much of the research and development work for the ALIGO machines was based on pioneering work for the GEO600 detector at Hannover, Germany. By February 2015, the detectors were brought into engineering mode in both locations.

By mid-September 2015 "the world's largest gravitational-wave facility" had completed a 5-year US$200-million overhaul at a total cost of $620 million. On September 18, 2015, Advanced LIGO began its first formal science observations at about four times the sensitivity of the initial LIGO interferometers. Its sensitivity will be further enhanced until it reaches the expected design sensitivity limits around 2021.

THE MISSION

LIGO's mission is to directly observe gravitational waves of cosmic origin. Their existence was indirectly confirmed when observations of the binary pulsar PSR 1913+16 in 1974 showed an orbital decay which matched Einstein's predictions of energy loss by gravitational radiation. The Nobel Prize in Physics 1993 was awarded to **Hulse and Taylor** for this discovery.



On February 11, 2016, the LIGO Scientific Collaboration and Virgo Collaboration published a paper about the detection of gravitational waves, from a signal detected at 09.51 UTC on 14 September 2015 of two ~30 solar mass black holes merging about 1.3 billion light-years from Earth.

Direct detection of gravitational waves has long been sought, as their discovery would launch a new branch of astronomy to complement electromagnetic telescopes and neutrino observatories. From Joseph Weber's pioneering efforts in the 1960s and papers published on wave resonance of light and gravitational waves, to the early 1990s, when physicists thought that technology had evolved to the point where detection of gravitational waves—of significant astrophysical interest—was now possible

In August 2002, LIGO began its search for cosmic gravitational waves. Measurable emissions of gravitational waves are expected from binary systems (collisions and coalescences of neutron stars or black holes), supernova explosions of massive stars (which form neutron stars and black holes), accreting neutron stars, rotations of neutron stars with deformed crusts, and the remnants of gravitational radiation created by the birth of the universe. The observatory may, in theory, also observe more exotic hypothetical phenomena, such as gravitational waves caused by oscillating cosmic strings or colliding domain walls.

LIGO operates two gravitational wave observatories in unison: the LIGO Livingston Observatory in Livingston, Louisiana, and the LIGO Hanford Observatory, on the DOE Hanford Site located near Richland, Washington. These sites are separated by 3,002 kilometres. Since gravitational waves are expected to travel at the speed of light, this distance corresponds to a difference in gravitational wave arrival times of up to ten milliseconds. Through the use of trilateration, the difference in arrival times helps to determine the source of the wave. Each observatory supports an L-shaped ultra high vacuum system, measuring 4 kilometres on each side. ⟶

LIGO-India, or INDIGO, is a planned collaborative project between the LIGO Laboratory and the Indian Initiative in Gravitational-wave Observations (IndIGO) to create another world-class gravitational-wave detector in India. AK