

The discovery of gravitational waves

1,3

billion years ago: the coalescence of two black holes generates a gravitational wave that starts travelling through space.

150

millions years ago: the coalescence of two neutron stars generates a gravitational wave that starts travelling through space.

1687

Isaac Newton publishes his work on "Philosophiæ naturalis Principia Mathematica" in which he describes the law of universal gravitation. Although this theory was able to accurately describe the motion of planets, it was unable to describe the way in which the gravitational force propagates between two bodies.

1915

Albert Einstein formulates the theory of general relativity which explains gravitational attraction as a consequence of the curvature of space-time. While for Newton, gravity is a force created by the presence of masses in space, for Einstein, gravity is a geometric effect of the curvature of space-time.

1916

As a consequence of his theory, Einstein predicts the existence of perturbations of space-time that propagate in space: gravitational waves. Einstein later concludes that they never would be observed.

1919

Arthur Eddington, during a total solar eclipse, observes one of the effects predicted by the theory of general relativity: the deflection of rays of light from stars when they pass in close proximity to the Sun. It is the first experimental proof of the theory of general relativity. Many other effects of general relativity have been subsequently observed.

1960

An American, Joseph Weber, builds the first instrument for the detection of gravitational waves: a resonant bar (or antenna).

1962

Two Russians, M.E. Gertsenhstein and V.I. Pustovoi, propose the detection of gravitational waves using interferometers.

1971

Edoardo Amaldi and Guido Pizzella create the first Italian National Institute for Nuclear Physics (INFN) group dedicated to the search for gravitational waves.

1980s

Rainer Weiss, Kip S. Thorne and Ronald W. P. Drever propose the construction of the LIGO interferometers.

The first resonant bars at temperatures very close to absolute zero (that is, very close to -273°C), designed to 'vibrate' with the passage of a gravitational wave, come into operation: Explorer at CERN (Switzerland), ALLEGRO in Louisiana (United States), Niobe in Perth (Australia), AURIGA at the National INFN Laboratories in Legnaro and NAUTILUS at the National INFN Laboratories in Frascati (Italy).

late 1980s

Adalberto Giazotto and Alain Brillet propose the construction of the VIRGO interferometer to the Italian INFN and to the French CNRS.

early 1990s

The International Gravitational Event Collaboration (IGEC) is born. It is the first international collaboration between cryogenic resonant antennas, in which data are exchanged between researchers in the involved countries.

1994

27th June Signature of the agreement between the Italian INFN and the French CNRS, for the construction of VIRGO.

1997

The construction of the VIRGO interferometer in Cascina (Pisa) begins.

2000

The European consortium for the search for gravitational waves, EGO - European Gravitational Observatory, is created. It has also the aim of promoting the participation of other European countries.

2002-10

First LIGO scientific data-taking campaign.

2003

End of the construction of the VIRGO interferometer.

2003-11

First Virgo scientific data-taking campaign. In the year 2007, the first agreement between LIGO and VIRGO is signed and the interferometer network is born. In April 2008, Advanced LIGO, and in December 2009, the Advanced VIRGO projects, are approved.

2012

23rd February Explorer completed its work in Hall 171 at CERN and leaves CERN to be put on display at EGO.

2015

End of the construction of Advanced LIGO, ten times more sensitive than its previous version, and the start of data-taking. The last resonant antennas (NAUTILUS and AURIGA) are turned off.

2015

14th September First detection of gravitational waves from the coalescence (fusion) of two black holes into a single black hole, of greater mass.

2017

In August, Advanced VIRGO comes into operation. The Advanced LIGOs and VIRGO network is thus fully operative.

2017

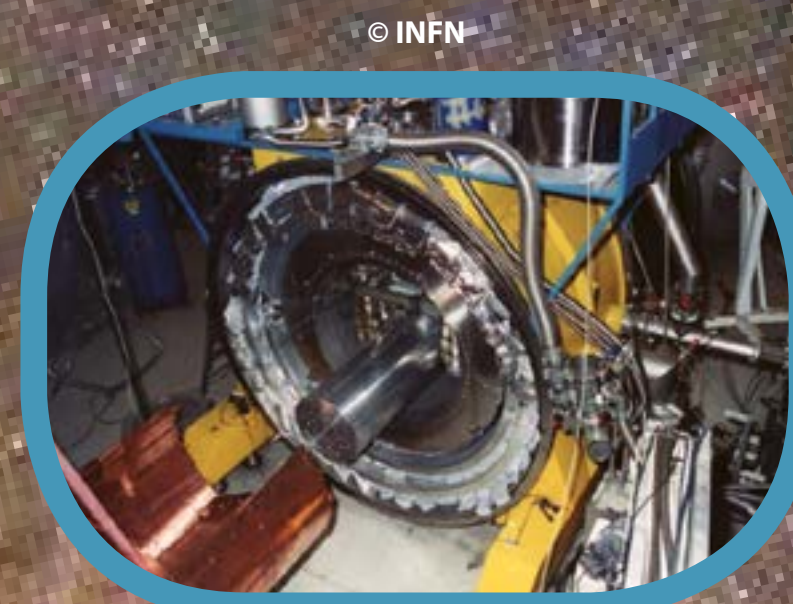
17th August First contemporary detection of gravitational and electromagnetic waves of a coalescence of neutron stars by Advanced VIRGO, LIGO and many terrestrial and space observatories. It is the beginning of a new era in physics: multimessenger astronomy is born.

2017

In October, the Nobel Prize in Physics is assigned to B. Barish, K. Thorne and R. Weiss for the discovery of gravitational waves.



Pizzella and Amaldi



Auriga at the National INFN Laboratories in Legnaro



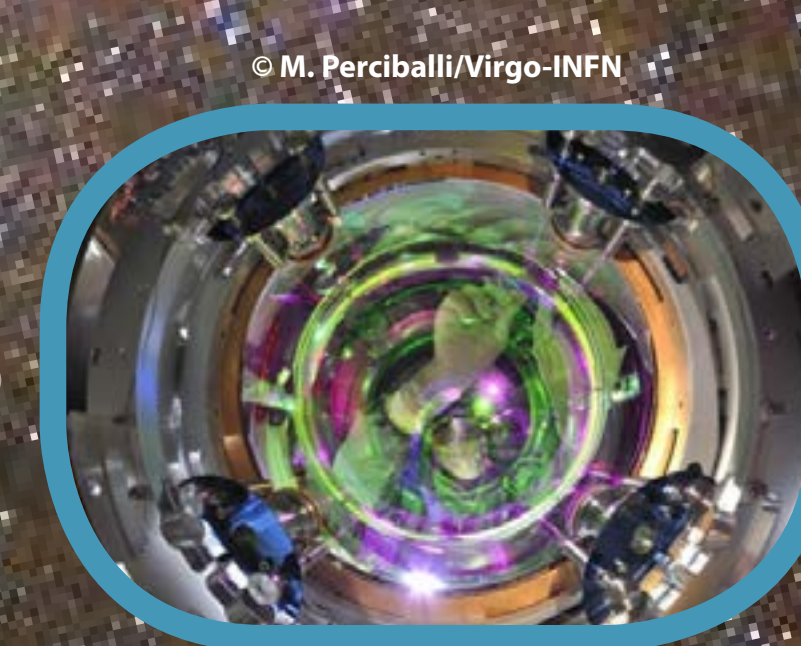
Giazotto and Brillet



VIRGO aerial view



Explorer at CERN



Advanced VIRGO Mirrors



Barish, Weiss and Thorne



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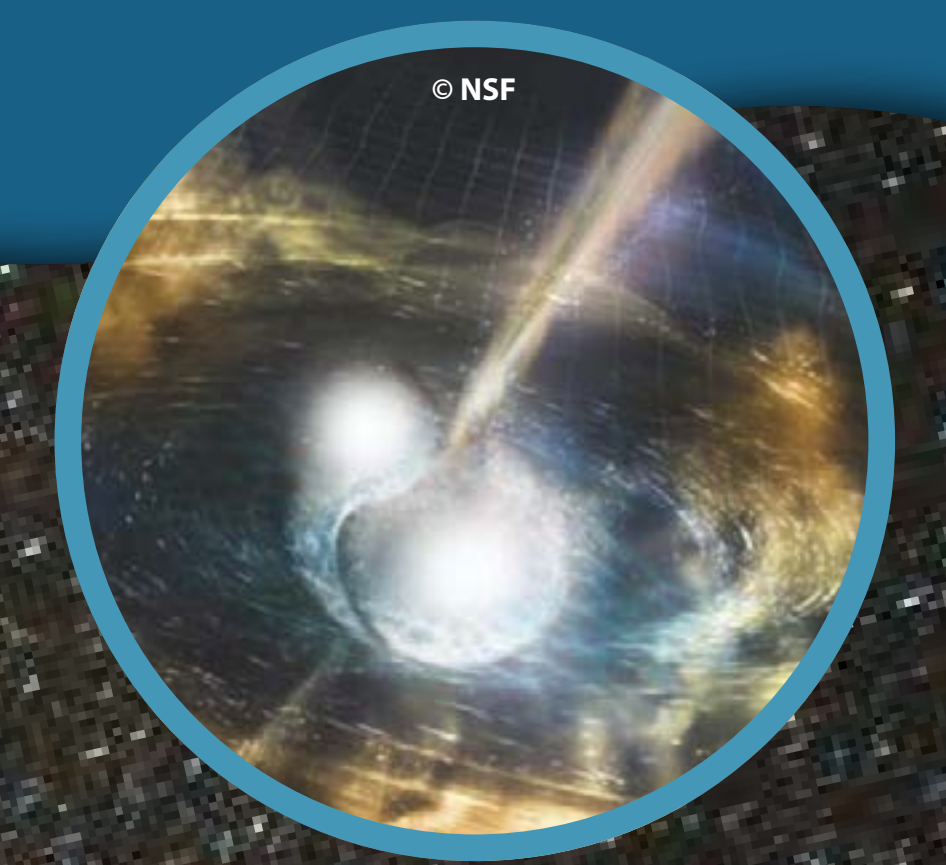
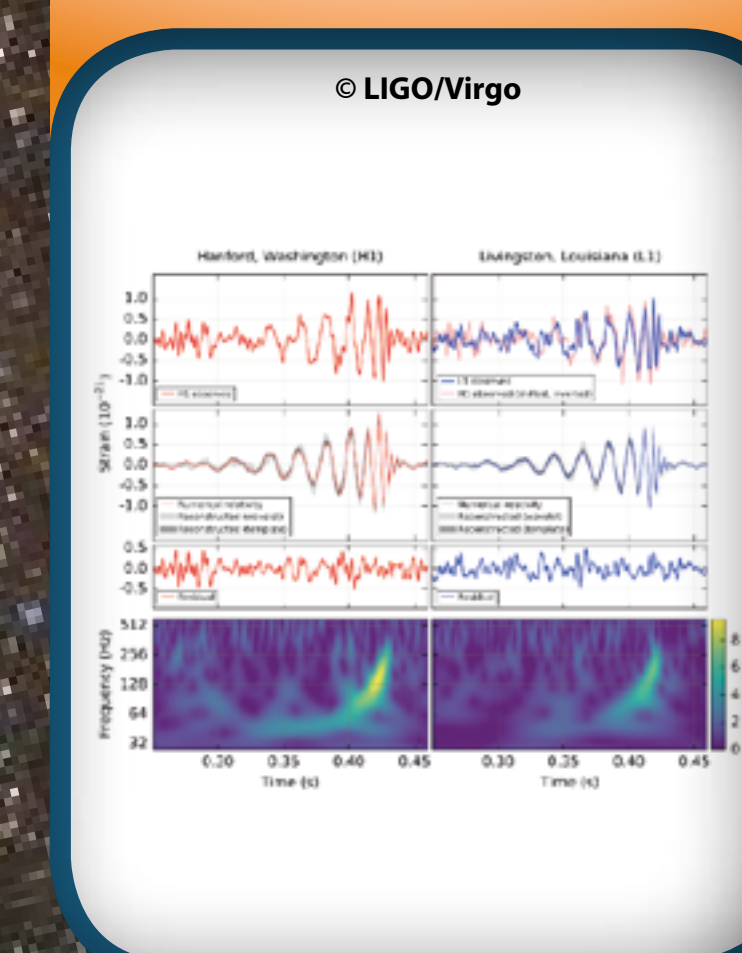
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2015 September 14th



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