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 “Philosophiae 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. Pustovoit, 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.

late 1980s 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).

1989 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 has 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

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Auriga at the National INFN Laboratories in Legnaro

Giazotto and Brillet

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VIRGO aerial view

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Explorer at CERN

© J. Giaime

Barish, Weiss and Thorne

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Advanced VIRGO Mirrors

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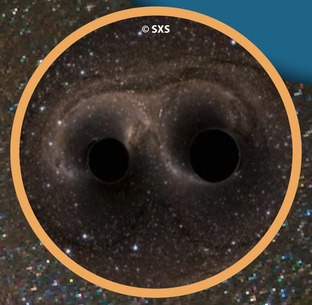

1,3 billion years ago

the coalescence of **two black holes** generates a gravitational wave that starts travelling through space...

...the signal generated reaches the Earth on

2015 September 14th

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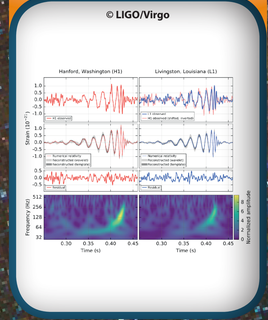

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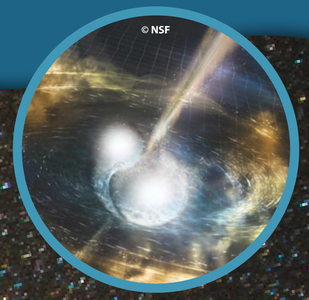

150 millions years ago

the coalescence of **two neutron stars** generates a gravitational wave that starts travelling through space...

...the signal generated reaches the Earth on

2017 August 17th

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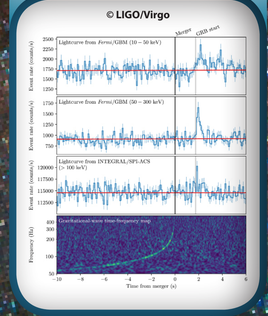

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