The gravitational wave universe

What are gravitational waves?

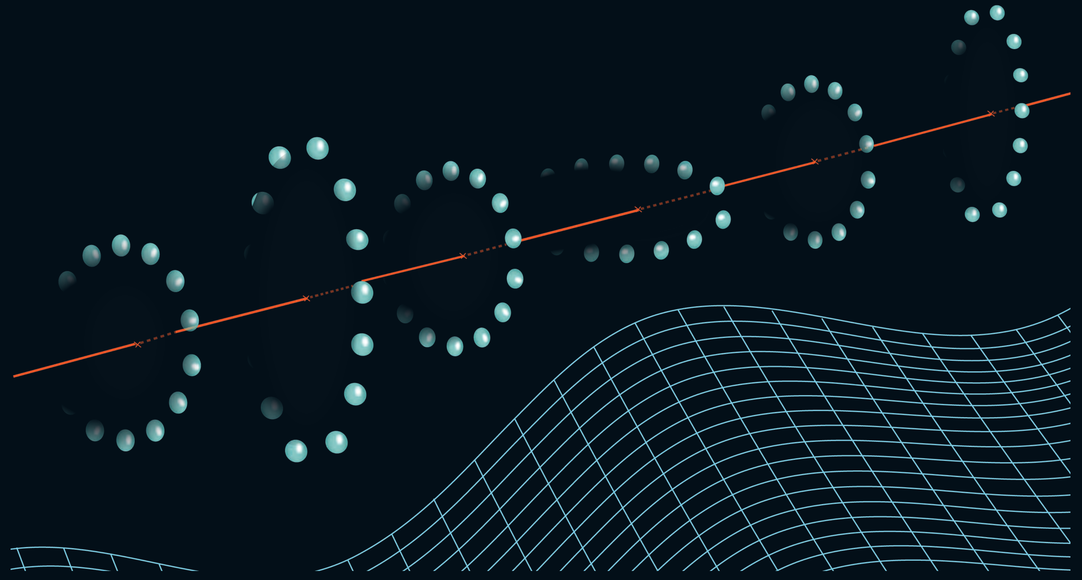
Gravitational waves are ripples in spacetime. They are generated by very heavy objects, such as two black holes that move around each other. This is a little bit like the way two people dancing in a swimming pool would produce waves on the water's surface.

Illustration of gravitational waves generated by binary neutron stars (ICCUB)

What are their effects?

In the picture we show (largely exaggerated) how a gravitational wave would slightly distort objects as it passes by.

The emitted waves are very weak when they reach Earth. Therefore, they are extremely difficult to measure. It is like trying to measure changes in the distance to Proxima Centauri (the closest star outside the solar system) comparable to the width of the human hair.



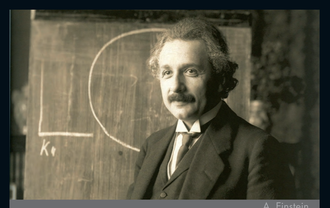
What can we learn from gravitational waves?

Gravitational waves - being essentially distinct from light - will give us a lot of information about our universe, about both its visible and its invisible parts. In particular, they will teach us how gravity works and how black holes form.

They are produced

» when very dense stars, so-called neutron stars, collide
» when stellar-mass black holes collide
» in supernova explosions
» when supermassive black holes collide during the merging of galaxies - the most violent phenomenon in our universe!

1916 — Prediction



A. Einstein (F. Schmutzer, [WC])

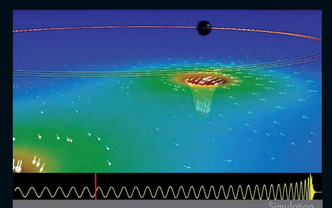
Einstein predicts the existence of gravitational waves. However, he does not believe that they can ever be detected.

1974 — Evidence

R. A. Hulse (Energy.gov) J. H. Taylor Jr. (Joanne H. Kim)

Hulse and Taylor find the first indirect evidence for gravitational waves. They observe how the orbit of two pulsars shrinks as they emit gravitational waves (1993 Nobel prize).

2005 — Simulation



Simulation (SXS Collaboration)

Computers simulate orbiting and colliding black holes and predict their gravitational wave signature for the first time. Thanks to this breakthrough we could predict the form of the gravitational waves that have been measured on Earth.