ICTS

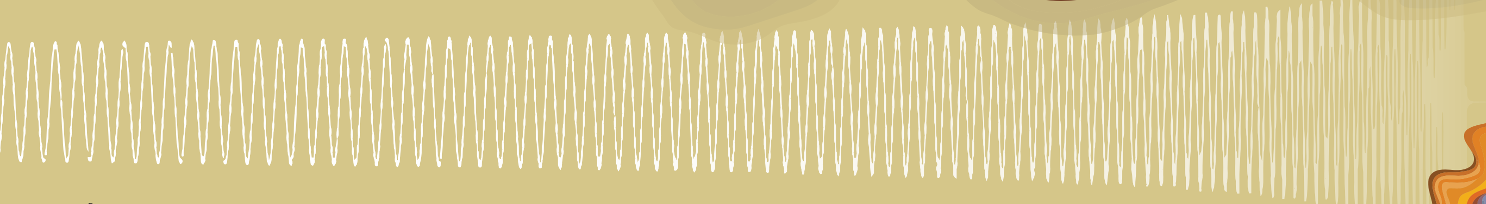
Binary neutron star merger GW170817:
A unique laboratory for fundamental physics, astrophysics and cosmology

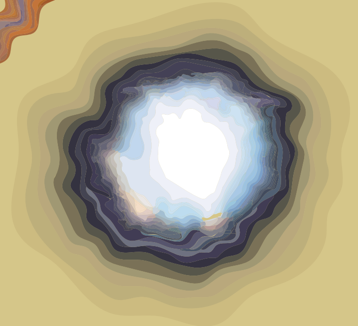
Neutron stars are the smallest, densest stars known to exist and are formed when massive stars explode in supernovae. Typical neutron stars are heavier than the Sun, but have a diameter of roughly 20 km – objects so dense that a teaspoon of material from a neutron star core weighs as much as a mountain!

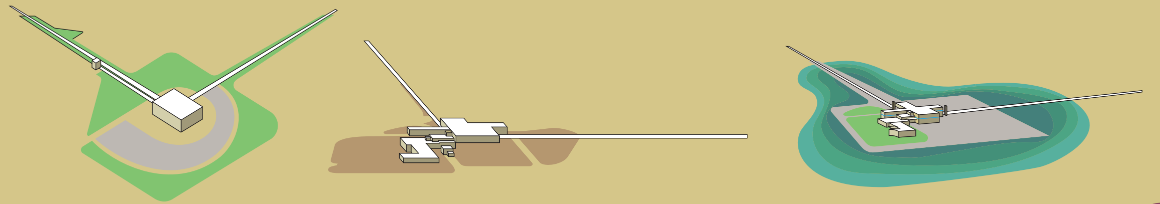
Matter in its densest form
In GW170817, the neutron stars, weighing about 1.1 to 1.6 times the mass of the Sun, were tracked for about 100 seconds as they spiraled towards each other and collided. These observations contain important clues about the nature of the dense matter that constitutes these stars — shedding light on a major puzzle in nuclear physics.

Neutron star mergers can be accompanied by spectacular emission of light from all parts of the electromagnetic spectrum — from gamma rays to radio waves. GW170817 was followed up by a variety of space- and ground-based telescopes marking the dawn of **multimessenger astronomy**.

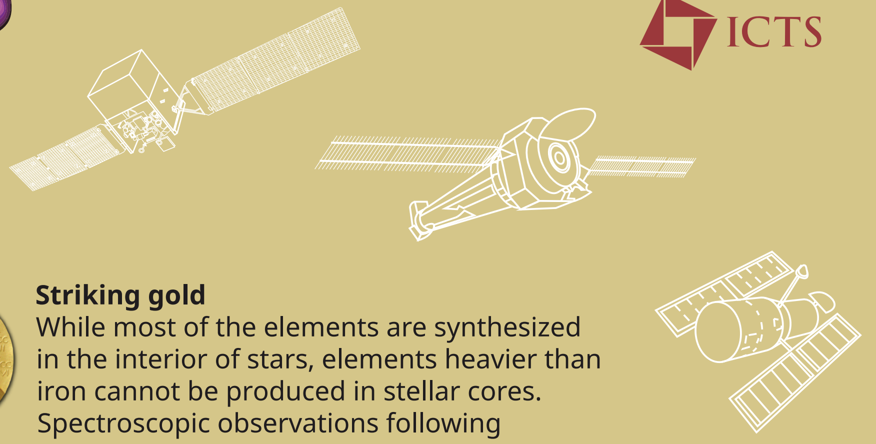
What are gamma-ray bursts?
Multimessenger observations of GW170817 show that at least some short gamma-ray bursts, the energetic flashes of gamma rays, are generated by the merger of neutron stars — something that was only theorized before.



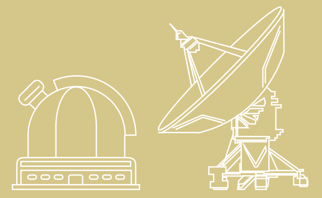




Striking gold
While most of the elements are synthesized in the interior of stars, elements heavier than iron cannot be produced in stellar cores. Spectroscopic observations following GW170817 have confirmed that neutron star mergers are indeed the birthplaces of half of the heavy elements – including most of the gold and platinum in the universe!



Einstein, right again!
The near-simultaneous arrival of gravitational waves and gamma rays from a source that is 130 million light years away confirms, to good accuracy, that gravitational waves indeed travel with the speed of light, as predicted by Einstein's theory.



LIGO and Virgo
LIGO gravitational-wave detectors are located in Hanford, Washington and Livingston, Louisiana in USA and Virgo is located in Pisa, Italy. They can detect displacements as small as $^{1}/_{1000^{th}}$ of the diameter of a proton.

Measuring the cosmic expansion rate
Astronomical observations of the last century told us that the universe is expanding, the exact nature of which is a major puzzle in cosmology. Joint gravitational and electromagnetic observations of GW170817 provide an independent way of measuring the local expansion rate of the universe, using a new cosmic ruler!

Drawings of the neutron star merger are inspired from visualizations by Bruno Giacomazzo (Univ. of Trento & INFN-TIFPA), Luciano Rezzolla (Frankfurt Univ.) and Ralf Kähler (ZIB). Courtesy – Albert Einstein Institute. | Nobel medal image courtesy – Wikipedia.