



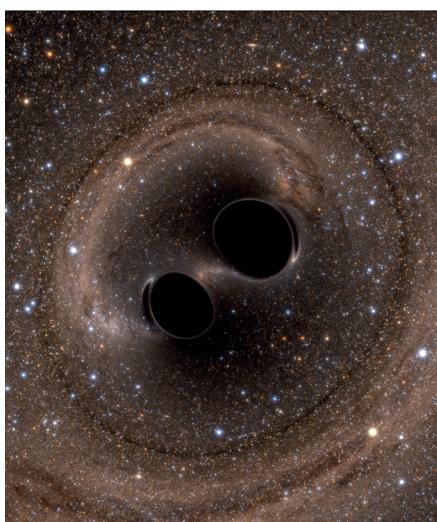
# GRAVITATIONAL WAVES

## Background

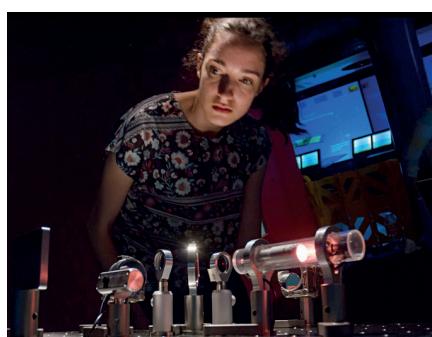
**THE NEW INSTITUTE OF GRAVITATIONAL WAVE ASTRONOMY AT THE UNIVERSITY OF BIRMINGHAM BRINGS TOGETHER EXPERTS FROM A WIDE RANGE OF DISCIPLINES WITHIN THE SCHOOL OF PHYSICS AND ASTRONOMY TO OPEN UP A NEW WINDOW ON THE UNIVERSE. OUR RESEARCH SPANS ALMOST ALL ASPECTS OF GRAVITATIONAL-WAVE SCIENCE, FROM LASER OPTICS AND ADVANCED NUMERICAL METHODS TO GENERAL RELATIVITY AND ASTROPHYSICS.**

The Birmingham group is involved in several high-profile, worldwide projects and collaborations:

- Laser Interferometer Gravitational-wave Observatory (LIGO)
- GEO 600
- Einstein Telescope
- LISA Pathfinder
- LISA
- European and International Pulsar Timing Arrays



- Gravitational waves are ripples in spacetime. When objects move, the curvature of spacetime changes. These changes propagate outwards (like ripples on a pond) as gravitational waves. A gravitational wave stretches and squashes space, so that it can be detected by measuring the change in separation between two objects.
- LIGO is a worldwide collaboration of over a thousand scientists and engineers.
- Gravitational waves from two black holes that orbited each other and then merged to form a bigger black hole were observed for the first time by the two LIGO detectors in September 2015.
- The gravitational waves detected were from an event that took place a billion years ago. By the time the waves reached Earth, the change in length of the 4-km LIGO arms was less than a 1000th of the size of a proton.



## Key messages

- The detection of gravitational waves by the LIGO team confirmed a fundamental prediction of Albert Einstein's general theory of relativity.
- The Birmingham group designed and produced parts for the LIGO detectors, developed new data analysis methods and characterised the properties of the binary black holes.

## The evidence

- The University has invested a record £6 million into the new Institute of Gravitational Wave Astronomy, the UK's first institute dedicated to gravitational wave astronomy.
- We have been instrumental to the LIGO collaboration since its inception, providing a wide spectrum of knowledge and expertise.
- Our scientists hold the leading positions on the key groups related to the discovery and have co-led many of the research papers linked to the discovery.

## Key projects

- The Einstein Telescope is a major European project with the aim to develop the next-generation observatory and our scientists are well positioned to make significant contributions.
- LISA, the space-based detector proposed by the European Space Agency will be able to make more accurate detections than Earth-based detectors.
- Scientists at Birmingham are members of the core team of LISA, the ESA's Laser Interferometer Space antenna, a 2.5 million km arm space instrument planned for launch in 2034. It will carry out precision measurements of gravitational waves from massive black holes – and many other sources – throughout the Universe.
- Advanced LIGO is now undergoing a series of upgrades and carrying out new observations. Full sensitivity is expected to be reached in 2020.

