## THE BIRMINGHAM GRAVITATIONAL WAVE GROUP

We are a young research group involved in a new branch of physics, which is interdisciplinary in nature. Bringing together expertise in experimental laser optics, gravitational physics and advanced theoretical methods, we are opening a new window on the Universe.

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## IN EINSTEIN'S FOOTSTEP

Gravitational waves are ripples of space-time. They are generated by violent cosmic events such as colliding black holes. Gravitational Wave Science makes use of a completely new type of large-scale instruments to capture these waves and study the dark side of the universe –hidden from direct observation before.

Our group, in collaboration with our British and German partners of the GEO collaboration, is at the forefront of this exciting new field. We are contributing to the development of Advanced LIGO, the most sensitive, km-sized gravitational wave observatory in the world. As part of a world-wide effort we are also working on even more powerful instruments to search deeper into the Universe: the Einstein Gravitational-wave Telescope, an European 10 km long, underground laser interferometer, and the Laser Interferometer Space Antenna, a ESA/NASA interferometer in space with 5-million km arms

## HUNTING GRAVITATIONAL WAVES WITH NEW DATA PROCESSING TECHNIQUES

Our powerful computer cluster allows us to look for the echoes of the most violent cosmic events such as black hole collisions and the Big Bang. These vibrations of the fabric of space-time are hidden in the data collected by the sensitive laser interferometers. These data sets are continuously transferred from the instrument sites to our storage systems in Birmingham.

Here they are analysed by our staff and students in the hunt for the elusive gravitational waves. Even using the most sensitive gravitational wave detectors, the expected signals will be hidden below a myriad of unavoidable disturbances ("noise"). We have developed new data processing techniques that will help us to discover black holes never seen before and to unravel the mysteries that they hold.

## DEVELOPMENT OF GRAVITATIONAL WAVE DETECTORS

Modern gravitational wave detectors are sophisticated, km-long laser interferometers. We are pioneering new concepts and technologies in laser optics to make the detection of such signals possible. Using computer models we combine the concepts of quantum optics with laser interferometry.

In our laboratories, we then build small-scale experiments to test these ideas in the real world. At the end of this process we implement new optical components and techniques in the interferometric gravitational wave detectors. We run these instruments in collaboration with our international partners (GEO600 in Germany, LIGO in the USA).

# A NEW ASTRONOMY

When in 1916 Albert Einstein predicted the existence of gravitational waves as an outcome of his General Theory of Relativity, he was convinced that these minute changes in the fabric of space-time would never be measurable. And still the direct detection of gravitational waves belongs to the most important open questions of modern science.

The direct observation of gravitational waves will open a new era in astronomy and cosmology, because gravitational wave detectors study the universe in a way different from any other observatory. It will bring totally new insights into our universe including clues as to its very beginning: For the first time it would be possible to cast an eye on the “cradle” of our universe. Gravitational waves will help to unveil the dark side of the universe, probing secrets from the Big Bang, Dark Matter and the far reaches of Einstein’s space-time.