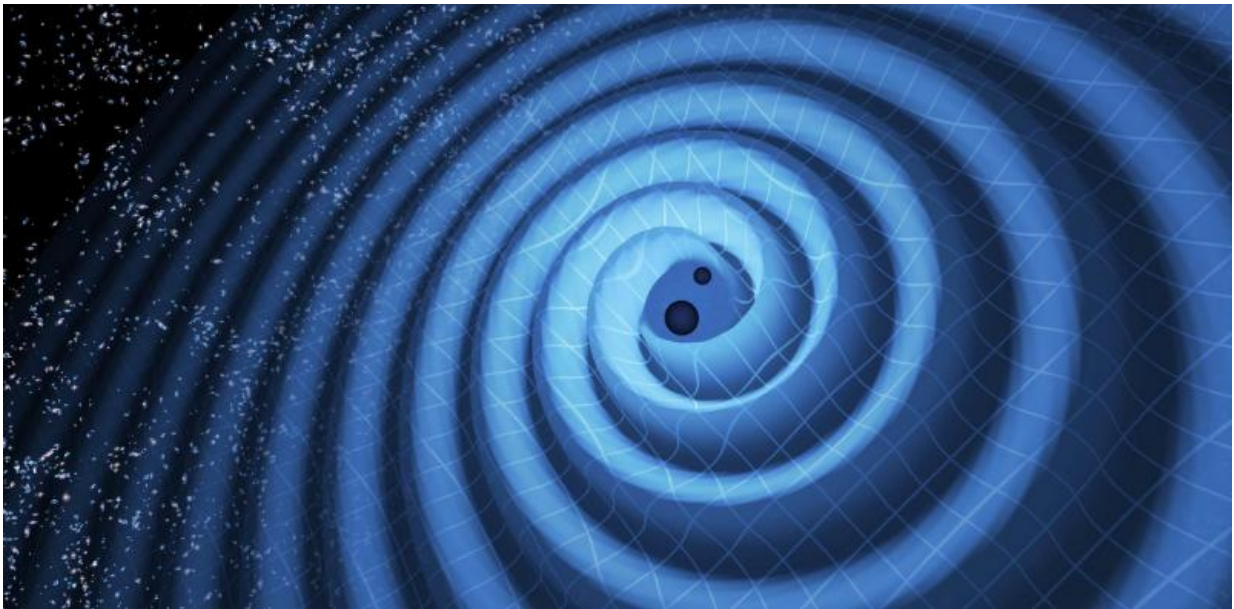


Second detection heralds the era of gravitational wave astronomy

June 17 2016, by Paul Lasky



An illustration showing the merger of two black holes and the gravitational waves that ripple outward. Credit: LIGO/T. Pyle

Earlier this year, a team of over 1,000 scientists from across the globe announced the first discovery of gravitational waves and the first ever observation of colliding black holes.

That same team has now [published](#) a second gravitational-wave observation from another cataclysmic black hole death spiral, detected

on Boxing Day, December 26, 2015. But what is the significance of this second [discovery](#), and what's its impact on astronomy?

Predicted by Albert Einstein, [gravitational waves](#) are tiny ripples in the fabric of [spacetime](#) caused by very heavy objects accelerating at very high speeds. The first detection of gravitational waves by the [LIGO Scientific Collaboration](#) came from two [black holes](#), each weighing about 30 times more than our sun, and travelling at approximately 60% the speed of light just prior to their collision.

This new system is similar to the first. The black holes that announced their merger on Boxing Day each weighed about ten times more than the sun. The catastrophic collision occurred more than a billion light years from Earth, and released one solar mass of energy in gravitational waves.

That is, the amount of gravitational-wave energy released during the merger was equivalent to obliterating the sun, and converting it into pure energy. Darth Vader's Death Star doesn't even compare!

Remarkably, this humongous amount of energy only caused the LIGO detectors to wobble by less than one thousandth the size of the nucleus of an atom.

Black holes are abundant

The observation of a second black hole merger implies there are many more black holes in the universe than most scientists had previously anticipated.

The uncertainty in the black hole merger rate is very large when you just have a single event, so we now know that we just didn't "get lucky" with the first detection.

There are going to be a lot of them. This is fantastic news for gravitational-wave astronomers.

First and foremost, it tells us that the future of gravitational-wave astronomy will be rich with scientific discoveries. Calculations suggest that we are likely to detect tens to hundreds of black hole mergers in the next two to three years, and thousands of mergers in the years to follow.

Ongoing technological advancements will continue to enhance the instrument's sensitivity. Planned technology upgrades will enable us to see these mergers to greater distances, increasing the detection rate by a factor of about 30.

But technology development will not stop there. Teams around the globe, including in Australia, are already working on next-generation technology to be implemented in future LIGO upgrades, resulting in even more detections.

More black holes than you can poke a stick at

Are we just being greedy? Now that we've observed two black hole mergers, what more could we want?

Well, it turns out that these first observations have raised as many questions as they've answered. Some questions we can only begin to attack by studying large populations of black hole mergers.

For example, we don't know how these systems form. It could be that both black holes are born separately in giant supernova explosions, and then find one another as they embark upon their cosmic wander in dense clusters of stars.

Alternatively they could be born together in binary star systems. This

currently open question could be answered once we have seen enough mergers.

Another exciting possibility is to use black holes to study the evolution of the universe as whole. When Australia's Brian Schmidt and colleagues won the Nobel Prize for showing that the expansion of the universe is accelerating, they did so using observations of supernovae in the distant universe.

Observations of populations of merging black holes with future instruments will be able to measure the expansion of the universe with unprecedented accuracy.

And if these potential discoveries aren't exciting enough, it turns out that spacetime has memory.

After a gravitational wave passes, spacetime is permanently deformed. That is, the distance between any two objects does not return to its original length – your body is permanently squeezed and stretched after the passage of a gravitational wave.

[New calculations](#) show that it will be possible to measure memory using future LIGO observations.

Before the first gravitational-wave discovery, we had never tested Einstein's relativity using such strong gravitational fields. Observing more black holes will allow us to test Einstein's theory and maybe detect a crack in his hitherto impenetrable armour.

This list of future developments is just scratching the surface of discovery space that is now open to us. Gravitational waves will reveal many more secrets of the universe in the coming years.

So the future of gravitational wave astronomy is bright and Australian scientists are fortunate to be part of this brand new and exciting field of discovery.

Continuing to invest in technology, infrastructure and data analysis development will further allow us to unveil other secrets of the universe; be it through observations of neutron star collisions, mountains on neutron stars, or even of the first moments of the universe itself.

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