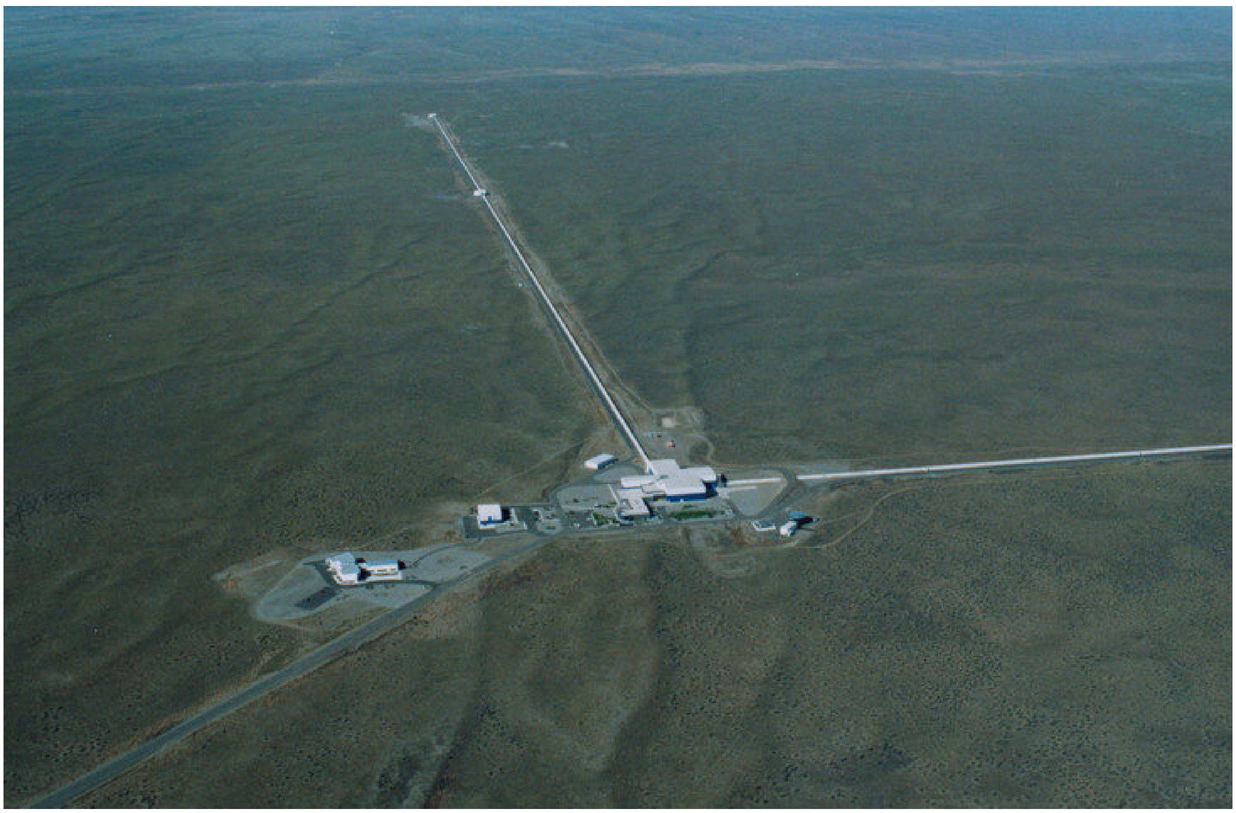
First-ever open public alerts now available from LIGO

April 23 2019, by Sam Sholtis



LIGO Laboratory operates two detector sites, one near Hanford in eastern Washington, and another near Livingston, Louisiana. This photo shows the Hanford detector site. Credit: Caltech/MIT/LIGO Lab

Two new probable gravitational waves—ripples in the fabric of spacetime caused by cataclysmic cosmic events and first predicted by

Albert Einstein over 100 years ago—have been detected by the Laser Interferometer Gravitational-Wave Observatory (LIGO) and the Virgo observatory in Italy in the first weeks after the detectors were updated. The source of both waves is believed to be the merging of a pair of black holes.

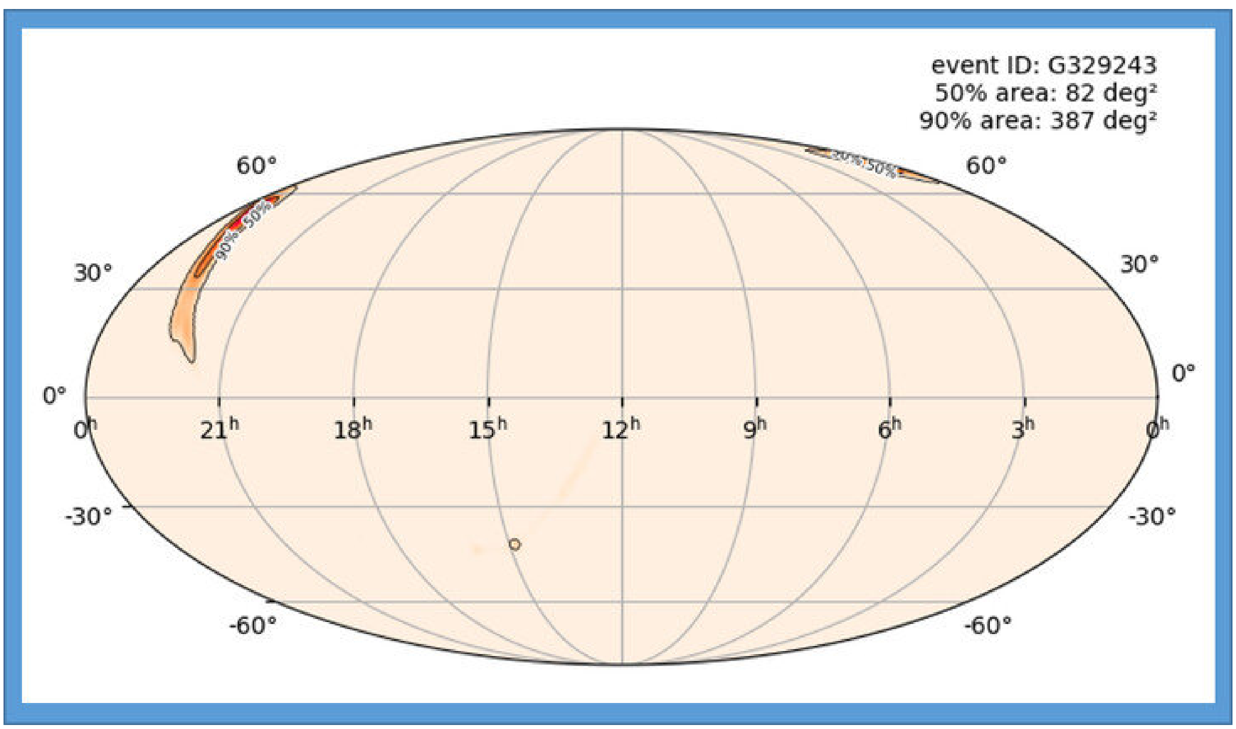
LIGO announced the discovery of the first new gravitational wave in its first-ever open public alert on April 8, and quickly followed up with a second announcement on April 12. LIGO detected the first-ever gravitational wave in September 2015, and announced the discovery in February 2016. Ten more gravitational waves were detected over the following three years, but with updates to LIGO and Virgo, scientists expect to see as many as one per week, which so far has proven true.

Updates to LIGO and Virgo have combined to increase its sensitivity by about 40 percent over its last run. Additionally, with this third observing run, LIGO and Virgo transitioned to a system whereby they alert the astronomy community almost immediately of a potential gravitational wave detection. This allows electromagnetic telescopes (X-ray, UV, optical, radio) to search for and hopefully find an electromagnetic signal from the same source, which can be key to understanding the dynamics of the event.

The Penn State team of LIGO scientists, led by Chad Hanna, associate professor of physics and of astronomy and astrophysics, Freed Early Career Professor, and Institute for CyberScience faculty co-hire at Penn State, played a critical role.

"Penn State is part of a small team of LIGO scientists that analyze the data in almost real-time," said Cody Messick, a graduate student in physics at Penn State and member of the LIGO team. "We are constantly comparing the data to hundreds of thousands of different possible gravitational waves and upload any significant candidates to a database as soon as possible. Although there are several different teams all performing similar analyses, the analysis ran by the Penn State team uploaded the candidates that were made public for both of these detections."

Messick has spent the last nine months working to ensure that uploaded gravitational wave candidates contain information from all of the detectors running at the time of a detection, even if the signal is extremely quiet in one of them. This helps with localizing the signals and has the potential to reduce the predicted area on the sky that the signal came from by over an order of magnitude. All of the LIGO public alerts will include a sky-map showing the possible location of the source on the sky, the time of the event, and what kind of event it is believed to be.



The region of sky believed to contain the source of the gravitational wave detected on April 8, 2019. The area spans 387 square degrees, equivalent to nearly 2000 full-Moons, roughly meandering through the constellations

Cassiopeia, Lacerta, Andromeda, and Cepheus in the northern hemisphere. Credit: LIGO/Caltech/MIT

"These are near real-time detections of gravitational waves produced from two probable black holes colliding," said Ryan Magee, a graduate student in physics at Penn State and member of the LIGO team. "We detected the first signal within about 20 seconds of its arrival to earth. We can set up automatic alerts to get phone calls and texts when a significant candidate is identified. I thought I was getting a spam phone call at first!"

The source of both gravitational waves is suspected to be compact binary mergers—the collision of two massive and incredibly dense cosmic objects into one another. Compact binary mergers can occur between two neutron stars, two black holes, or a neutron star and a black hole. Each of these different types of mergers create gravitational waves with strikingly different signals, so the LIGO team can identify the type of event that created the gravitational waves.

"With the updates to LIGO, I expect to see more signals," said Magee. "I would really like to see a neutron star-black hole merger, which hasn't been observed yet."

LIGO consists of two massive detectors approximately 3,000 kilometers apart, one in Livingston, Louisiana, and one in Hanford, Washington. The signal from both gravitational waves was detected at both observatories as well as the Virgo gravitational wave observatory in Italy, and immediately made public.

"This is the first LIGO observation that was made public right away in an automated fashion," said Surabhi Sachdev, Eberly Postdoctoral

Research Fellow in physics at Penn State and member of the LIGO team. "This is the new LIGO policy starting with this observing run. Events are instantly made public automatically. After human vetting, a confirmation or retraction is issued within hours."

In addition to Hanna, Messick, Magee and Sachdev, the LIGO team working on these discoveries at Penn State includes Bangalore Sathyaprakash, Patrick Godwin, Alex Pace, Ssohrab Borhanian, Anuradha Gupta, Becca Ewing, Divya Singh and Rachael Huxford.

Provided by Pennsylvania State University

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