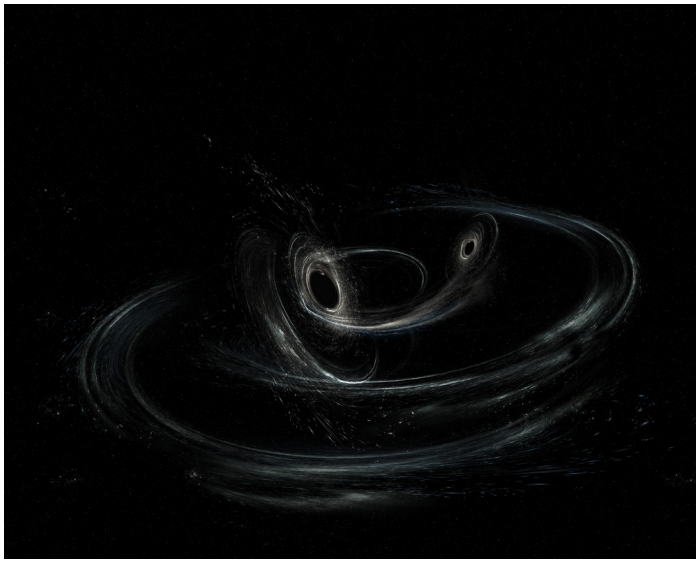
PennState

New gravity waves hit Earth after record-breaking trip through space



Before the Merge: Spiraling Black Holes. This artist's conception shows two merging black holes similar to those detected by LIGO. The black holes — which will ultimately spiral together into one larger black hole — are shown orbiting one another in a plane. They are spinning in a non-aligned fashion, which means they have different orientations relative to the overall orbital motion of the pair. There is a hint of this phenomenon found by LIGO in at least one black hole of the GW170104 system. ***IMAGE: LIGO/CALTECH/MIT/SONOMA STATE (AURORE SIMONNET)***

Barbara K. Kennedy, Penn State, and David Shoemaker, LIGO

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UNIVERSITY PARK, Pa. — Gravitational waves produced by the birth of a

massive black hole, a record-breaking billions of light-years from Earth, have been detected by the Laser Interferometer Gravitational-wave Observatory (LIGO). The waves were generated when two smaller black holes collided and then merged to form a larger black hole with a mass about 50 times larger than our sun's.

Researchers at the Institute for Gravitation and the Cosmos at Penn State provided leadership in this discovery, as well as in LIGO's previous detections. B.S. Sathyaprakash, the Elsbach Professor of Physics and professor of astronomy and astrophysics, played a key role in the characterization of the sources. He is one of the two leaders of the editorial process for the paper describing the discovery, which has been accepted for publication in the journal Physical Review Letters. Chad Hanna, assistant professor of physics and astronomy and astrophysics and Freed Early Career Professor at Penn State, served as the co-chair of LIGO's Compact Binary Coalescence Group, which detected the three gravitational waves discovered thus far.

"This new achievement indicates that LIGO's success in detecting gravitational waves truly has opened the door to an entirely new field of astrophysics research," Hanna said.

LIGO made the first-ever direct observation of gravitational waves in September 2015 and the second detection in December 2015. This new detection, called GW170104, occurred on January 4, 2017. "LIGO's first three detections now already have established that there likely is a population of black holes in the universe with masses greater than previously expected," said Hanna.

"We now have further confirmation of the existence of stellar-mass black holes that are larger than 20 solar masses — these are objects we didn't know existed before LIGO detected them," said MIT's David Shoemaker, spokesperson for the LIGO Scientific Collaboration (LSC), a body of more than 1,000 international scientists who perform LIGO research together with the European-based Virgo Collaboration. "It is remarkable that humans can put together a story, and test it, for such strange and extreme events that took place billions of years ago and billions of light-years distant from us."

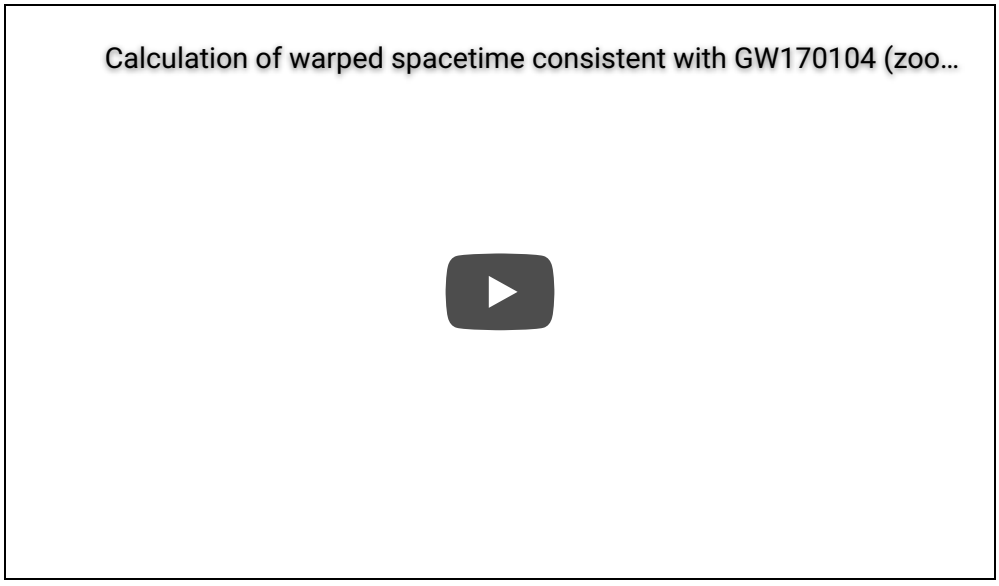
The new detection also revealed some hints about the orientation of the spins of the two smaller black holes shortly before they merged. "This is the first time that we have evidence that the black holes may not be aligned, giving us just a tiny hint that binary black holes may form in dense stellar clusters," said Sathyaprakash. More observations with LIGO are needed in order to say

anything definitive about the spins of binary black holes, but these early data offer clues about how these pairs may form.

The new paper is coauthored by LIGO and the Virgo Collaboration, which operates a gravitational-wave interferometer with similar detection goals as LIGO's. Virgo and the LIGO Scientific Community work together in many areas and have an agreement on the exchange of data.

LIGO observations are carried out by twin detectors — one in Hanford, Washington, and the other in Livingston, Louisiana — operated by Caltech and MIT with funding from the National Science Foundation (NSF). The LIGO Laboratory is funded by the NSF, and operated by Caltech and MIT, which conceived and built the observatory. The NSF led in financial support for the Advanced LIGO project with funding organizations in Germany (MPG), the U.K. (STFC) and Australia (ARC) making significant commitments to the project.

More than 1,000 scientists from around the world participate in the effort through the LIGO Scientific Collaboration, which includes the GEO Collaboration. LIGO partners with the Virgo Collaboration, which is supported by Centre National de la Recherche Scientifique (CNRS), Istituto Nazionale di Fisica Nucleare (INFN) and Nikhef, as well as Virgo's host institution, the European Gravitational Observatory, a consortium that includes 280 additional scientists throughout Europe. Additional partners are listed at: http://ligo.org/partners.php.



Black Holes: Animation of warped spacetime consistent with GW170104 detection of 2 black holes merging

Simulation of warped spacetime consistent with GW170104. A mathematical calculation of the warped spacetime near two merging black holes. The simulation is consistent with LIGO's observation of the

binary black hole coalesence event GW170104. The colored bands are gravitational-wave peaks and troughs, with the colors getting brighter as the wave amplitude increases. The throats near the center of the movie indicate the strong spacetime warping near the black holes' event horizons. See this link for a zoomed-out version of this animation.

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