LIGO Detects Gravitational Waves for Third Time
Press Release for GW170104
Translated into Siksika (Blackfoot)

LIGO Detects Gravitational Waves for Third Time
Results confirm new population of black holes

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The Laser Interferometer Gravitational-wave Observatory (LIGO) has made a third detection of gravitational waves, ripples in space and time, demonstrating that a new window in astronomy has been firmly opened. As was the case with the first two detections, the waves were generated when two black holes collided to form a larger black hole.

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The newfound black hole, formed by the merger, has a mass about 49 times that of our sun. This fills in a gap between the masses of the two merged black holes detected previously by LIGO, with solar masses of 62 (first detection) and 21 (second detection).

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"We 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," says MIT's David Shoemaker, the newly elected 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 entire LIGO and Virgo scientific collaborations worked to put all these pieces together."

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The new detection occurred during LIGO's current observing run, which began November 30, 2016, and will continue through the summer. LIGO is an international collaboration with members around the globe. Its 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).

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LIGO made the first-ever direct observation of gravitational waves in September 2015 during its first observing run since undergoing major upgrades in a program called Advanced LIGO. The second detection was made in December 2015. The third detection, called GW170104 and made on January 4, 2017, is described in a new paper accepted for publication in the journal *Physical Review Letters*.

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In all three cases, each of the twin detectors of LIGO detected gravitational waves from the tremendously energetic mergers of black hole pairs. These are collisions that produce more power than is radiated as light by all the stars and galaxies in the universe at any given time. The recent detection appears to be the farthest yet, with the black holes located about 3 billion light-years away. (The black holes in the first and second detections are located 1.3 and 1.4 billion light-years away, respectively.)

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The newest observation also provides clues about the directions in which the black holes are spinning. As pairs of black holes spiral around each other, they also spin on their own axes—like a pair of ice skaters spinning individually while also circling around each other. Sometimes black holes spin in the same overall orbital direction as the pair is moving—what astronomers refer to as aligned spins—and sometimes they spin in the opposite direction of the orbital motion. What's more, black holes can also be tilted away from the orbital plane. Essentially, black holes can spin in any direction.

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The new LIGO data cannot determine if the recently observed black holes were tilted but they imply that at least one of the black holes may have been non-aligned compared to the overall orbital motion. More observations with LIGO are needed to say anything definitive about the spins of binary black holes, but these early data offer clues about how these pairs may form.

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"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," says Bangalore Sathyaprakash of Penn State and Cardiff University, one of the editors of the new paper, which is authored by the entire LSC and Virgo Collaborations.

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There are two primary models to explain how binary pairs of black holes can be formed. The first model proposes that the black holes are born together: they form when each star in a pair of stars explodes, and then, because the original stars were spinning in alignment, the black holes likely remain aligned.

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In the other model, the black holes come together later in life within crowded stellar clusters. The black holes pair up after they sink to the center of a star cluster. In this scenario, the black holes can spin in any direction relative to their orbital motion. Because LIGO sees some evidence that the GW170104 black holes are non-aligned, the data slightly favor this dense stellar cluster theory.

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"We're starting to gather real statistics on binary black hole systems," says Keita Kawabe of Caltech, also an editor of the paper, who is based at the LIGO Hanford Observatory. "That's interesting because some models of black hole binary formation are somewhat favored over the others even now and, in the future, we can further narrow this down."

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The study also once again puts Albert Einstein's theories to the test. For example, the researchers looked for an effect called dispersion, which occurs when light waves in a physical medium such as glass travel at different speeds depending on their wavelength; this is how a prism creates a rainbow. Einstein's general theory of relativity forbids dispersion from happening in gravitational waves as they propagate from their source to Earth. LIGO did not find evidence for this effect.

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"It looks like Einstein was right—even for this new event, which is about two times farther away than our first detection," says Laura Cadonati of Georgia Tech and the Deputy Spokesperson of the LSC. "We can see no deviation from the predictions of general relativity, and this greater distance helps us to make that statement with more confidence."

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“The LIGO instruments have reached impressive sensitivities,” notes Jo van den Brand, the Virgo Collaboration spokesperson, a physicist at the Dutch National Institute for Subatomic Physics (Nikhef) and professor at VU University in Amsterdam. "We expect that by this summer Virgo, the European interferometer, will expand the network of detectors, helping us to better localize the signals.”

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The LIGO-Virgo team is continuing to search the latest LIGO data for signs of space-time ripples from the far reaches of the cosmos. They are also working on technical upgrades for LIGO's next run, scheduled to begin in late 2018, during which the detectors' sensitivity will be improved.

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"With the third confirmed detection of gravitational waves from the collision of two black holes, LIGO is establishing itself as a powerful observatory for revealing the dark side of the universe," says David Reitze of Caltech, executive director of the LIGO Laboratory. "While LIGO is uniquely suited to observing these types of events, we hope to see other types of astrophysical events soon, such as the violent collision of two neutron stars."

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** This is a translation into the Siksika (Blackfoot) language by Sharon Yellowfly (Siksika Nation) who has a Bachelor's of Arts in Anthropology, a background in linguistics, & who is fluent in the Siksika language. This translation was made from a Blackfoot Dictionary Yellowfly has written. Words are spelled phoenetically with the English alphabet, but here are notes on vowels & other symbols used to make sounds unique to the Siksika language:*

Vowels & Other Sounds

SIKSIKA	ENGLISH
a	*f**a**ther*
i	***ea**t*
u	*b**oo**k*
e	*l**e**t*
o	*g**o***

x - *si**x***	**?** - glottal stop
A - ***a**corn*	**_** - as in '***he***' but held a little longer
I - ***i**ce*	* - *who*
	~ - (not quite a full glottal stop) as in '*cotton*'

LIGO is funded by the National Science Foundation (NSF), and operated by MIT and Caltech, which conceived and built the project. Financial support for the Advanced LIGO project was led by NSF with Germany (Max Planck Society), the U.K. (Science and Technology Facilities Council) and Australia (Australian Research Council) making significant commitments and contributions 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, a consortium including 280 additional scientists throughout Europe supported by the Centre National de la Recherche Scientifique (CNRS), the Istituto Nazionale di Fisica Nucleare (INFN), and Nikhef, as well as Virgo's host institution, the European Gravitational Observatory. Additional partners are listed at: http://ligo.org/partners.php.

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