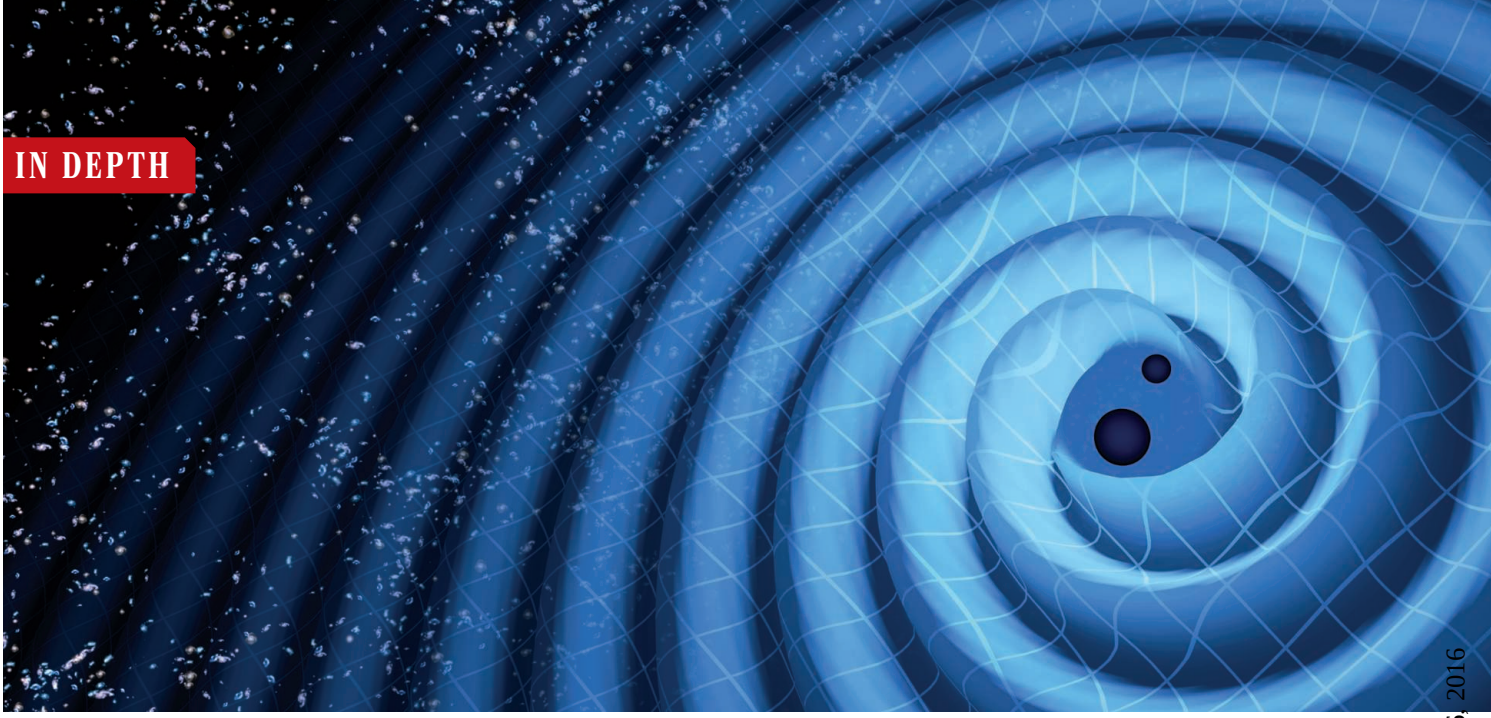


IN DEPTH

ASTROPHYSICS

LIGO detects another black hole crash

Second gravitational-wave detection augurs bumper crop of sightings

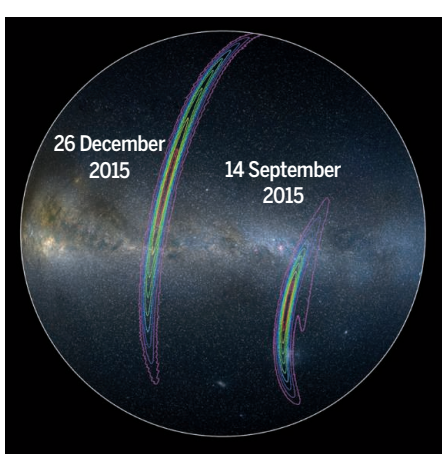
By **Adrian Cho**

The biggest discovery in science this year—the observation of ripples in space-time called gravitational waves—was no fluke. For a second time, physicists working with the two massive detectors in the Laser Interferometer Gravitational-Wave Observatory (LIGO) have detected a pulse of such waves, the LIGO team reported on 15 June at a meeting of the American Astronomical Society in San Diego, California. Once again the waves emanated from the merger of two black holes, the ultraintense gravitational fields left behind when massive stars collapse into infinitesimal points. The new observation suggests that after fine-tuning, LIGO will spot dozens or even hundreds of the otherwise undetectable events each year.

"It's very reassuring," says Gabriela González, a physicist at Louisiana State University, Baton Rouge, and chair of the 1000-member LIGO Scientific Collaboration. "You need another one to be completely convinced and this is it." Cole Miller, an astrophysicist at the University of Maryland, College Park, who is not a member of the collaboration, says that the new find shows that LIGO "is genuinely a new window on the universe." Astrophysicists' catalog of stellar-mass black holes, he says, "is going to be overwhelmingly increased by LIGO."

The new observation came at 3:38.53 Coordinated Universal Time on 26 December 2015—late on Christmas day at LIGO's detectors in Livingston, Louisiana, and Hanford, Washington. As in the first event, the detectors sensed an oscillating stretching of space-time, the signal, according to Einstein's general theory of relativity, of massive objects in violent motion. Computer modeling indicated that its source was two black holes spiraling together about 1.4 billion light-years away. (LIGO researchers had seen a weaker signal on 12 October 2015 that may be a third black hole merger.)

The first signal LIGO spied, recorded in September 2015 and unveiled to the world in February (*Science*, 12 February, p. 645), emanated from surprisingly heavy black holes, with masses 36 and 29 times that of the sun. It lasted only 0.2 seconds, and physicists glimpsed only the last 10 cycles of the black holes' spiraling motion before their collision. The December 2015 sighting involved smaller black holes, 14 and 7.5 times as heavy as the sun. Physicists witnessed 55 cycles of the death spiral, a full second.



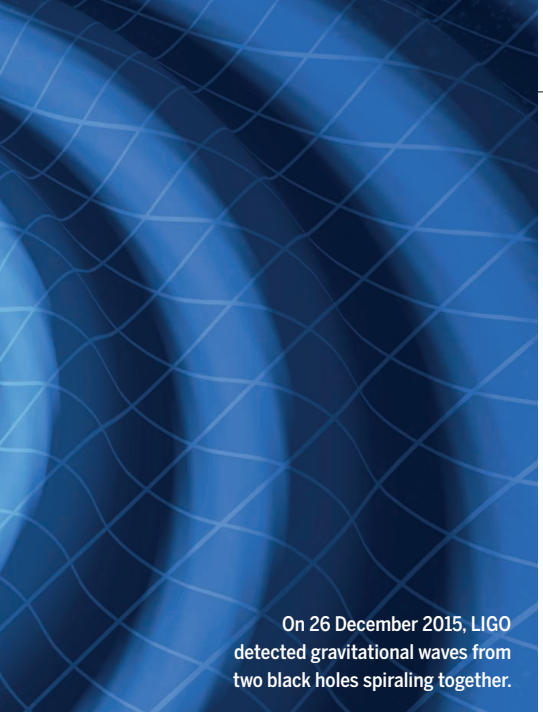
The gravitational waves that LIGO has detected originated in the southern sky. The purple and yellow lines define the likely signal source regions.

The first observation remains a riddle. Those two black holes were twice as massive as the relatively nearby stellar-mass black holes identified from the x-rays emitted by hot gas swirling into them. Astrophysicists don't know how such jumbo black holes formed. The black holes in the new event "are much more garden variety," says Sebastian Heinz, an astrophysicist at the University of Wisconsin, Madison.

Nevertheless, the latest event yields new insights. For example, physicists determined that one of the black holes was spinning frenetically, at roughly 20% of the maximum spin rate allowed by general relativity. And because the new event includes many more cycles, it tests predictions of general relativity somewhat more stringently than the first event, González says. (Einstein's theory passes the test.)

Most important, the second observation shows that going forward, LIGO should reap a vast harvest of black hole mergers. Rebuilt from 2010 to 2015, the new LIGO detectors have not yet reached their design sensitivity. If they do, they should see as many as

IMAGES: (TOP TO BOTTOM) LIGO/T. PYLE; LIGO/AXEL MELLINGER



On 26 December 2015, LIGO detected gravitational waves from two black holes spiraling together.

PHOTO: AP PHOTO/FELIPE DANA

one black hole merger per day, estimates Stephen Fairhurst, a gravitational-wave astrophysicist and LIGO team member at Cardiff University in the United Kingdom. The resulting sample should lay bare the mysterious evolution of black hole binaries, he says, showing whether they start out as pairs of stars that turn into black holes or as black holes that form independently and ultimately find each other.

Reaching the design sensitivity—a factor of 2.5 better than today's—is a challenge, as the instruments currently suffer from a "mystery noise" at low frequencies. David Reitze, LIGO's executive director at the California Institute of Technology in Pasadena, says he's cautiously optimistic that physicists can eliminate the noise and reach design sensitivity by 2019. "I won't say with 100% confidence that we will get there, but I won't say that we won't either," he says.

Physicists hope LIGO will eventually detect waves from other kinds of cosmic collisions. Mergers involving neutron stars, for example, would plumb the mysterious physics of these objects, which are essentially gigantic atomic nuclei with masses between 1.5 and three times that of the sun. LIGO physicists are combing their data for such signals, but finding them is a long shot at the present sensitivity, González says.

LIGO's next big splash will likely come in 2017. The detectors, now restarting after tune-ups, are expected to begin a second data run this fall. They should also be joined by the revamped VIRGO detector, an interferometer near Pisa, Italy, that will help pinpoint sources in the sky and measure their distances. LIGO may well have more surprises in store, Heinz says: "There's always that great possibility of finding something unexpected." ■

INFECTIOUS DISEASE

Experts fear Zika's effects may be even worse than thought

Doctors and researchers are scrambling to define "Zika congenital syndrome"

By **Gretchen Vogel**

Zika keeps unveiling menacing new talents. For many years the virus was thought to cause only mild symptoms. Then, in July 2015 doctors in northeast Brazil noticed a spike in cases of microcephaly, or unusually small heads, showing up in ultrasound examinations of pregnant women. Many of the women reported having had a fever or the rash typical of Zika infection, which had started spreading in the region a few months earlier. In April, the U.S. Centers for Disease Control and Prevention concluded that Zika virus causes this brain defect, which can result in developmental and learning disabilities. Now, case reports make it increasingly clear that babies infected in utero also have problems in their eyes, ears, limbs, and perhaps other organs.

"It seems there are a broader range of effects that go beyond microcephaly," says Tarun Dua, who is helping cooordinate the response to Zika at the World Health Organization (WHO) in Geneva, Switzerland. Earlier this month WHO announced that it is launching an effort to characterize what doctors are now calling Zika congenital syndrome. "We are looking at many thousands of babies, and we need a systematic process for defining their symptoms," Dua says.

Animal- and cell-based studies have shown that Zika virus readily infects the cells of the nervous system, which would explain most of the symptoms identified so far. "We've been learning very bad things on a weekly basis," says Paolo Zanotto, a virologist at the University of São Paulo in Brazil. He notes that the damage is so extensive in some cases that the skull has filled mostly with fluid, and "there is no brain." Those babies die shortly after birth. Other infants may have only mild brain damage that will not be apparent until learning disabilities or other problems show up years later.

Doctors focusing on microcephaly may miss significant problems. On 7 June, doctors in Recife, Brazil, reported in *The Lancet* that they had diagnosed brain damage and scars on the retina of a 2-month-old baby that did not have microcephaly but did have limb spasms shortly after it was born. A brain scan revealed significant defects, including ventricles that were larger than normal and brain tissue that was smoother than it should be. The mother reported no symptoms of Zika infection during pregnancy. However, further tests showed that the baby had antibodies to the virus in its cerebrospinal fluid, strong evi-

A physician in Recife, Brazil, examines the brain scans of a baby born with microcephaly.

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Editor's Summary