LIGO and Virgo Announce Four New Gravitational-Wave Detections

The observatories are also releasing their first catalog of gravitational-wave events

On Saturday, scientists attending the Gravitational Wave Physics and Astronomy Workshop in College Park, Maryland presented new results from searches for coalescing cosmic objects, such as pairs of black holes and pairs of neutron stars, by the National Science Foundation's LIGO (Laser Interferometer Gravitational-Wave Observatory) and the European-based VIRGO gravitational-wave detector. The LIGO and Virgo collaborations have now confidently detected gravitational waves from a total of 10 stellar-mass binary black hole mergers and one merger of neutron stars, which are the dense, spherical remains of stellar explosions. Seven of these events had been reported before, while four of the black hole detections are newly announced.

From September 12, 2015, to January 19, 2016, during the first LIGO observing run since undergoing upgrades in a program called Advanced LIGO, gravitational waves from three binary black hole mergers were detected. The second observing run, which lasted from November 30, 2016, to August 25, 2017, yielded a binary neutron star merger and seven additional binary black hole mergers, including the four new gravitational wave events being reported now. The new events are known as GW170729, GW170809, GW170818 and GW170823 based on the dates on which they were detected.

The new event GW170729, detected in the second observing run on July 29, 2017, is the most massive and distant gravitational-wave source ever observed. In this coalescence, which happened roughly 5 billion years ago, an equivalent energy of almost five solar masses was converted into gravitational radiation.

The Virgo interferometer joined the two LIGO detectors on August 1, 2017, while LIGO was in its second observing run. Although the LIGO-Virgo three-detector network was operational for only three-and-a-half weeks, five events were observed in this period. Two events detected jointly by LIGO and Virgo, GW170814 and GW170817, have already been reported. GW170814 was the first binary black hole merger measured by the three-detector network, and allowed for first tests of gravitational-wave polarization (analogous to light polarization). Three days later, the event GW170817 was detected. This was the first time that gravitational waves were ever observed from the merger of a binary neutron star system. What's more, this collision was seen in gravitational waves and light, and marked an exciting new chapter in multi-messenger astronomy, in which cosmic objects are observed simultaneously in different forms of radiation.

One of the new events, GW170818, detected by the global network formed by the LIGO and Virgo observatories (located in the United States and Italy, respectively), was very precisely pinpointed in the sky. The position of the binary black holes, located 2.5 billion light-years from Earth, was identified in the sky with a precision of 39 square degrees. That makes it the next best localized gravitational-wave source after the GW170817 neutron star merger.

“It is gratifying to see the new capabilities that become available through the addition of Advanced Virgo to the global network,” says Jo van den Brand of Nikhef (the Dutch National Institute for Subatomic Physics) and VU University Amsterdam, who is the spokesperson for the Virgo collaboration. “Especially our greatly improved pointing precision will allow astronomers to rapidly find any other cosmic messengers emitted by the gravitational wave sources.” This success is made possible by exploiting the pointing capability of the network, which uses the time delays of the signal arrival at the different sites and the so-called antenna patterns of the interferometers.

Caltech's Albert Lazzarini, Deputy Director of the LIGO Laboratory, says "The release of 4 additional binary black hole mergers further informs us of the nature of the population of these binary systems in the Universe and better constrains the event rate for this type of events." "The next observing run, starting in Spring 2019, should yield many more gravitational-wave candidates, and the science the community can accomplish will grow accordingly" says David Shoemaker, spokesperson for the LIGO Scientific Collaboration and senior research scientist in MIT's Kavli Institute for Astrophysics and Space Research. "It's an incredibly exciting time."

"The new catalog is another proof of the exemplary international collaboration of the gravitational wave community and an asset for the forthcoming runs and upgrades" adds EGO Director Stavros Katsanevas.

A total of 11 confident gravitational-wave detections were obtained by three independent analyses of the O1 and O2 data. "This gravitational-wave catalog is the reward for a tremendous effort by the LIGO and Virgo collaborations. It has been an absolute privilege to be part of this endeavor and work with so many incredibly talented scientists to achieve this fantastic result," says Patricia Schmidt, research fellow at Radboud University Nijmegen, the Netherlands.

The scientific paper describing these new findings, which is being published today on the arXiv repository of electronic preprints, presents detailed information in the form of a catalog of all the gravitational wave detections and candidate events of the two observing runs. Thanks to more advanced data processing and better calibration of the instruments, the accuracy of the astrophysical parameters of the previously announced events increased considerably.

"The results of the first two observing runs demonstrate the huge capabilities of the gravitational-wave network to make science", says Viviana Fafone, INFN coordinator for the Virgo Collaboration. "This catalog marks the transition from the first pioneering detections to the systematic exploitation of gravitational waves sources for science" adds Benoit Mours, CNRS coordinator for the Virgo Collaboration.

The Collaborations

LIGO is funded by NSF and operated by Caltech and MIT, 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-OzGrav) making significant commitments and contributions to the project. More than 1,200 scientists from around the world participate in the effort through the LIGO Scientific Collaboration, which includes the GEO Collaboration. A list of additional partners is available at http://ligo.org/partners.php.

The Virgo collaboration consists of more than 300 physicists and engineers belonging to 28 different European research groups: six from Centre National de la Recherche Scientifique (CNRS) in France; 11 from the Istituto Nazionale di Fisica Nucleare (INFN) in Italy;

two in the Netherlands with Nikhef; the MTA Wigner RCP in Hungary; the POLGRAW group in Poland; Spain with IFAE and the Universities of Valencia and Barcelona; two in Belgium with the Universities of Liege and Louvain; Jena University in Germany; and the European Gravitational Observatory, EGO, the laboratory hosting the Virgo detector near Pisa in Italy, funded by CNRS, INFN, and Nikhef. A list of the Virgo Collaboration can be found at http://public.virgo-gw.eu/the-virgo-collaboration/. More information is available on the Virgo website at www.virgo-gw.eu.

Related links

The LIGO Scientific Collaboration and the Virgo Collaboration, "*GWTC-1: A Gravitational-Wave Transient Catalog of Compact Binary Mergers Observed by LIGO and Virgo during the First and Second Observing Runs*"

The LIGO Scientific Collaboration and the Virgo Collaboration, "*Binary Black Hole Population Properties Inferred from the First and Second Observing Runs of Advanced LIGO and Advanced Virgo*"

Media Contacts

Valerio Boschi
Virgo-EGO Communication Office
valerio.boschi@ego-gw.it; +39 050 752 463

Antonella Varaschin
INFN Communications Office
antonella.varaschin@presid.infn.it ; +39 06 68400360

Julien Guillaume
CNRS Press Office
julien.guillaume@cnrs.fr; + 33 1 44 96 46 35

Kimberly Allen
Director of Media Relations and
Deputy Director, MIT News Office
allenkc@mit.edu; +1 617-253-2702

Whitney Clavin
Senior Content and Media Strategist
Caltech Communications
wclavin@caltech.edu; +1 626-395-1856

John Toon
Institute Research and Economic Development Communications
Georgia Institute of Technology
john.toon@comm.gatech.edu; +1 404-894-6986

Amanda Hallberg Greenwell
Head, Office of Legislative and Public Affairs
National Science Foundation
agreenwe@nsf.gov; +1 703-292-8070