



National Science Foundation  
WHERE DISCOVERIES BEGIN



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News Release 15-056

# Newly dedicated observatory to search for gravitational waves

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First run scheduled for fall 2015



Northern arm of the LIGO interferometer on Hanford facility in Richland, Washington

[Credit and Larger Version \(/news/news\\_images.jsp?cntn\\_id=135190&org=NSF\)](/news/news_images.jsp?cntn_id=135190&org=NSF)

**May 19, 2015**

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Seeking to expand how we observe and understand the universe where we live, the National Science Foundation today helped dedicate the Advanced Laser Gravitational Wave Observatories (Advanced LIGO) at the LIGO Hanford facility in Richland, Wash.

The California Institute of Technology and Massachusetts Institute of Technology designed the NSF-funded facilities and operate them with the goal of observing and recording gravitational waves for the first time. Those discoveries would allow us to learn more about the phenomena, such as supernovae and colliding black holes, that generate the waves.

The Advanced LIGO project represents a major upgrade expected to enhance the sensitivity of LIGO's instruments by a factor of at least 10, creating a one thousand-fold increase in the number of astrophysical candidates for gravitational wave signals. After today's dedication, Advanced LIGO will undergo

commissioning to ensure instrumentation is ready for its first search for gravitational waves sometime this autumn.

“Advanced LIGO represents a critically important step forward in our continuing effort to understand the extraordinary mysteries of our universe,” said NSF Director France A. Córdova. “It gives scientists a highly sophisticated instrument for detecting gravitational waves, which we believe carry with them information about their dynamic origins and about the nature of gravity that cannot be obtained by conventional astronomical tools.”

### **The ripple of Einstein’s vision**

Predicted by Albert Einstein in 1916 as a consequence of his theory of General Relativity, gravitational waves are ripples in the fabric of space and time produced by violent events in the distant universe—for example, by the collision of two black holes or by supernovae explosions. Gravitational waves are emitted by accelerating masses in much the same way as radio waves are produced by accelerating charges, such as electrons in antennas.

As gravitational waves travel to Earth, these ripples in the space-time fabric bring with them information about their violent origins and about the nature of gravity that cannot be obtained by other astronomical tools.

Although scientists have yet to detect them directly, the influence of gravitational wave emissions on a binary pulsar system (two neutron stars orbiting each other) has been measured accurately and is in excellent agreement with predictions. In 1993, Russell Hulse and Joseph Taylor received the Nobel Prize for this work (performed in the '70s and '80s). Scientists therefore have great confidence that gravitational waves exist.

“This is an exciting time that is quite similar to when the astronomy community introduced radio astronomy,” said Denise Caldwell, NSF division director for physics. “In much the same way that radio astronomy added another dimension to how scientists could observe celestial phenomena, Advanced LIGO also offers yet another, different perspective. We have found that each time we open a new window of observation, we are able to make discoveries that lead us to a new frontier.”

### **How LIGO has advanced**

LIGO was originally proposed in the 1980s as a means of detecting gravitational waves. The instrument is comprised of two 4-kilometer length L-shaped devices known as “interferometers” – one at Hanford, the other at the LIGO observatory in Livingston, La.

Inside the LIGO interferometers are vacuum tubes in which a laser beam is split into two beams. Those beams travel back and forth along the length of the tubes, going between precisely configured and very sensitive mirrors located near the vertex and at the end of each arm of the “L.” According to Einstein’s theory, as a gravitational wave passes by, the path the laser beam takes between the mirrors will vary slightly. That change indicates the presence of the gravitational wave. The configuration is sensitive enough to detect a remarkably minute change. LIGO could detect a change equivalent to one-thousandth the size of a proton diameter; Advanced LIGO, which will utilize LIGO’s upgraded infrastructure, will be 10 times more sensitive.

“To achieve this improvement, we took many lessons learned from initial LIGO, put them together with the results of worldwide R&D, and made a complete re-design and replacement of the detectors,” said David Shoemaker of MIT, the project leader for Advanced LIGO.

To upgrade LIGO to this level of sensitivity required changes in the lasers, optics and several other components and processes. Additionally, these upgrades also significantly improve the instrumentation’s sensitive frequency range and facilitate the ability to tune it for specific astrophysical sources. This will allow Advanced LIGO to look at the last minutes of life of pairs of massive black holes as they spiral closer,

coalesce into one larger black hole, and then vibrate –much like two soap bubbles – to become one. The increased frequency range that comes with Advanced LIGO at 10 to 1000 Hertz significantly widens the window to detect signals from coalescing black holes and pulsars that previously couldn't be observed.

Advanced LIGO will also be used to search for the gravitational cosmic background, allowing tests of theories about the universe's development less than a nanosecond after the Big Bang.

### **Worldwide commitment to world-class research**

The LIGO Scientific Collaboration (LSC), which carries out this work, is a group of some 950 scientists at universities around the United States and in 15 other countries. The LSC network includes the LIGO interferometers and the GEO600 interferometer, a project located near Hannover, Germany, designed and operated by scientists from Max Planck Institute for Gravitational Physics, along with partners in the United Kingdom funded by the Science and Technology Facilities Council (STFC). Additionally, a new node of the LIGO network in India may be operational around 2022.

The LSC works jointly with the Virgo Collaboration — which designed and constructed the 3-km long Virgo interferometer located in Cascina, Italy — to analyze data from the LIGO, GEO600 and Virgo interferometers.

International partners have contributed equipment, labor and expertise, including Britain's Science and Technology Facilities Council supplying the suspension assembly and some mirror optics; the Max Planck Society of Germany providing the high-power, high-stability laser; and an Australian consortium of universities supported by the Australian Research Council offering systems for initially positioning and measuring in place the optics curvature to nanometer precision.

"It's exactly this breadth of perspective that increases our chances to succeed at this monumental undertaking," said Fleming Crim, NSF assistant director for the mathematical and physical sciences directorate. "The level of commitment from all the partners in Advanced LIGO is a testament to the magnitude of discovery that scientists believe is possible from this unique instrumentation."

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### **Media Contacts**

Ivy F. Kupec, NSF, (703) 292-8796, [ikupec@nsf.gov](mailto:ikupec@nsf.gov) (<mailto:ikupec@nsf.gov>)

### **Program Contacts**

Mark W. Coles, NSF, (703) 292-4432, [mcoles@nsf.gov](mailto:mcoles@nsf.gov) (<mailto:mcoles@nsf.gov>)

Pedro Marronetti, NSF, (703) 292-7372, [pmarrone@nsf.gov](mailto:pmarrone@nsf.gov) (<mailto:pmarrone@nsf.gov>)

### **Related Websites**

Advanced LIGO: <https://www.advancedligo.mit.edu/> ([/cgi-bin/good-bye?https://www.advancedligo.mit.edu/](https://www.advancedligo.mit.edu/))

LIGO Scientific Collaboration: <http://www.ligo.org/> ([/cgi-bin/good-bye?http://www.ligo.org/](http://www.ligo.org/))

LIGO: <http://www.ligo.caltech.edu/> ([/cgi-bin/good-bye?http://www.ligo.caltech.edu/](http://www.ligo.caltech.edu/))

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National Science Foundation, 2415 Eisenhower Avenue, Alexandria, Virginia 22314, USA Tel: (703) 292-5111, FIRS:  
(800) 877-8339 | TDD: (800) 281-8749