NSF News
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LIGO: The Search for Gravitational Waves

The National Science Foundation (NSF) provides funding for large, multi-user facilities that provide researchers and educators with access to the latest technological tools and capabilities. NSF supports far-reaching areas of science and engineering that hold promise for breakthroughs that will enhance the nation's future in profound, and possibly unpredictable, ways. The Laser Interferometer Gravitational-Wave Observatory (LIGO), which begins scientific operations in late June 2002, is an example.

LIGO aims to:

- **Take risks.** Investing in leading-edge research and education is a future-oriented endeavor, which involves taking risks. Increasingly, it requires international collaborations and integrating knowledge across traditional disciplinary boundaries. And, as science achieves measurements once considered nearly impossible, it requires technological innovations that were barely conceived of even a few decades ago.

- **Study the universe.** For many years, telescopes that detect and measure electromagnetic waves, including visible light, have been the primary means for astronomers and physicists to study the universe. Because of NSF's investments, scientists now are reaching out with an entirely new means of exploration -- detectors of gravitational waves.

- **Measure faint signals.** Gravitational waves are produced by violent events throughout the universe. LIGO is designed to detect and measure these faintest of signals reaching Earth from space and, at the same time, test fundamental predictions of physics. In the process, the LIGO project is spearheading the new field of gravitational-wave astronomy.

- **Observe directly.** Though Albert Einstein predicted the existence of gravitational waves in 1918 in his general theory of relativity, they have never been directly observed. LIGO, designed to measure displacements as small as one-thousandth of the diameter of a proton, is expected to provide the first hard evidence. By measuring the effects of those waves, scientists hope to find evidence that will enrich our understanding of phenomena such as black holes, supernovae and pulsars.

- **Network internationally.** LIGO is the largest single enterprise undertaken by NSF, with capital costs of nearly $300 million and operating costs of more than $20 million/year. Scientists from around the world collaborated on its design and scientific objectives. LIGO is the first of an international network of detectors that together will extract the maximum amount of information about the sources of gravitational waves.

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- **Create spin-offs.** In addition to its direct objectives, LIGO is reaping far-reaching scientific, technological and industrial benefits. A laser developed for LIGO by Stanford University scientists, for example, has many potential applications. Other spin-offs are expected in areas such as measurement science, seismic isolation, vacuum technology, crystal growth, coatings and optics.

- **Educate.** Educational outreach ensures that the new knowledge reaches teachers and students, encouraging the nation's next generation of scientists. Middle schools, high schools, colleges and universities are participating in LIGO outreach programs. Opportunities are available for students and teachers to analyze LIGO data, contributing to knowledge about phenomena such as seismic and atmospheric disturbances and weather; to participate in software development; and to conduct hands-on research alongside scientists that will visit LIGO from around the globe.

Status. Construction of the LIGO facilities at Hanford, Washington, and Livingston, Louisiana, is complete. The three interferometers (two at Hanford and one in Livingston) have been operated successfully alone and "in coincidence" with each other and with interferometers in Germany and Japan and with a "bar"-type detector in Louisiana. Running in coincidence is essential for detecting gravitational waves. Commissioning of the LIGO instruments has continued to improve sensitivity and running time. The first round of scientific observations is scheduled to begin June 29.

Players. LIGO is headed by a team from the California Institute of Technology and the Massachusetts Institute of Technology. The LIGO scientific collaboration consists of more than 350 scientists from more than 30 institutions worldwide.

For more information, see: *http://www.ligo.caltech.edu/*

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June 2002