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March 11, 1991

Dr. Paul A. Vanden Bout, Director
National Radio Astronomy Observatory
Edgemont Road
Charlottesville, VA 22903-2475

Dear Sir:

Your office has recently submitted a proposal in response to the LIGO Site Solicitation Announcement. The attached news release, made by Caltech in connection with the LIGO Site Solicitation, is furnished for your information.

Sincerely,

W. E. Althouse

William E. Althouse
Chief Engineer, LIGO Project

WEA/ca

Enclosure

California Institute of Technology

Office of Public Relations
Pasadena, California 91125
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For Immediate Release

March 11, 1991

Eighteen Sites Proposed For Gravity-Wave Observatory

PASADENA -- The California Institute of Technology has received proposals for eighteen sites in seventeen states as possible locations for the Laser Interferometer Gravitational-Wave Observatory (LIGO), announced Rochus E. Vogt, Caltech's R. Stanton Avery Distinguished Service Professor and Professor of Physics and Director of the LIGO project.

"Based on a cursory review, I am very impressed with the quality of the proposals," said Vogt. "It is clear that a number of people in the country are excited about LIGO and have worked hard to produce these proposals. We went through an extensive process to secure proposals by contacting all 50 governors to provide information and requirements for the sites. These proposals are a result of that process."

When complete, LIGO (a joint effort of scientists from Caltech and MIT) will consist of two detector facilities in the United States, located far apart but operated as a single observatory. The total project is expected to cost about $211 million. Each detector facility will consist of a 4-foot-diameter vacuum pipe arranged in the shape of an L with 4-kilometer (2.5-mile) arms. A semi-cylindrical reinforced concrete vault enclosure will protect the specially made low-hydrogen-steel vacuum pipes. Located at the vertex of the two arms, and at the midpoint and outer end of each arm, will be buildings housing most of the equipment for the laser interferometric sensor systems.

LIGO will be funded through the National Science Foundation (NSF), which has been supporting research and development to establish the feasibility of LIGO since 1979. The National Science Board gave its approval for construction on May 10, 1990. President Bush's proposed fiscal year 1992 budget allocates $23.5 million for initial work on LIGO.

Now that the site proposals are in hand, Vogt will set up a group to evaluate all candidate sites for technical feasibility, scientific suitability, and costs. Subsequently, sites will be paired, based upon scientific requirements including separation and orientation.

Additional investigations of these pairs may be conducted. Analyses and recommendations will be submitted to NSF, which will make the final selection of sites. "It's difficult to say at this stage how long this process will take," said Vogt. "It will certainly be a period of months. We want to be ready to begin construction early in 1992 if Congress appropriates the funds."

The sites proposed are:

STATE	SUBMITTING ORGANIZATION	LOCATION
California	County of Los Angeles	Pearblossom, CA
Idaho	State of Idaho	Idaho National Engineering Laboratory (Department of Energy)
Kansas	Garden City Chamber of Commerce	Garden City, KS
Louisiana	Livingston Economic Development Council	Livingston, LA
Maine	State of Maine	Columbia, ME
Mississippi	State of Mississippi	NASA Stennis Space Center
Montana	State of Montana	Comanche Basin, MT
Nebraska	State of Nebraska	Mead, NE
New Mexico	State of New Mexico	Tatum, NM
New Mexico	New Mexico State University	Las Cruces, NM
New York	Syracuse University	Romulus, NY
North Dakota	State of North Dakota	Amidon, ND
South Carolina	State of South Carolina	Savannah River (DOE)
Tennessee	State of Tennessee	Eagleville, TN
Utah	State of Utah	Skull Valley, UT
Washington	Hanford Reservation	Hanford (DOE)
West Virginia	National Radio Astronomy Observatory	Green Bank, WV
Wyoming	State of Wyoming	Carpenter, WY

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Laser Interferometer Gravitational-Wave Observatory (LIGO)

Fact Sheet

What is LIGO?

LIGO will be a facility dedicated to the detection of cosmic gravitational waves and the harnessing of these waves for scientific research. It will consist of two widely separated installations within the United States, operated in unison as a single observatory. When it reaches maturity, this observatory will be open for use by the national community, and will become part of a planned worldwide network of gravitational-wave observatories.

Who will build LIGO?

LIGO will be designed and constructed by a team of scientists from the California Institute of Technology and the Massachusetts Institute of Technology. Prototypes of laser-interferometric gravitational wave detectors have been built and are operating at both institutions.

What are gravitational waves?

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 the cores of supernova explosions. Gravitational waves are emitted by accelerating masses much as electromagnetic waves are produced by accelerating charges. These ripples in the space-time fabric travel to Earth, bringing with them information about their violent origins and about the nature of gravity. Albert Einstein predicted the existence of these gravitational waves in 1916 in his general theory of relativity, but only now, in the 1990s, has technology become powerful enough to permit detecting them and harnessing them for science. Although they have not yet been detected directly, the influence of gravitational waves on a binary pulsar (two neutron stars orbiting each other) has been measured accurately by Joseph Taylor and colleagues at Princeton University, and is in good agreement with the predictions. Scientists therefore have great confidence that gravitational waves exist.

What are LIGO's scientific goals?

LIGO will be used for research into the nature of gravity, and it will open up an entirely new window onto the universe. It will thus be a scientific tool both for physics and for astronomy.

Possible payoffs for physics

General relativity describes gravity as a manifestation of the curvature of space-time. This description has been tested and proved correct in the solar system, where gravity is weak and changes slowly due to the orbital motions of planets and their satellites. LIGO will permit scientists to test this description for rapidly changing, dynamical gravity (the space-time ripples of the gravitational waves), and also for the extremely strong, dynamical gravity of two black holes as they collide. More specifically, LIGO has the possibility to:

- Verify directly general relativity's prediction that gravitational waves exist.
- Test general relativity's prediction that these waves propagate at the

same speed as light, and that the graviton (the fundamental particle that accompanies these waves) has zero rest mass.

♦ Test general relativity's prediction that the forces the waves exert on matter are perpendicular to the waves' direction of travel, and stretch matter along one perpendicular direction while squeezing it along the other; and, also thereby test general relativity's prediction that the graviton has twice the rate of spin as the photon.

♦ Firmly verify that black holes exist, and test general relativity's predictions for the violently pulsating space-time curvature accompanying the collision of two black holes. This will be the most stringent test ever of Einstein's general relativity theory.

Possible payoffs for astronomy

Almost all our present information about the distant universe comes from electromagnetic waves. Until the 1940s, the only such waves accessible to astronomers were light waves; and optical telescopes, studying them, revealed a serene universe of planets, stars, and galaxies. In the 1940s, 1950s, and 1960s the march of technology made possible radio telescopes, infrared telescopes, and x-ray telescopes, which look at cosmic electromagnetic waves that have wavelengths different from light. Because these radiations differed from light, they brought us new kinds of information about the universe: they revealed the universe's violent side--quasars, pulsars, and the birth throes of stars, for example. Gravitational waves, being radically different from all electromagnetic waves, have the potential to create yet another revolution in our understanding of the universe. Among the things they might reveal are these:

♦ The spiralling together and coalescence of pairs of neutron stars (stars made of nearly pure nuclear matter); and in some cases the implosion of the coalesced star to form a black hole.

♦ The swallowing of a neutron star by a black hole, and the collisions and coalescences of black holes.

♦ The birth of a neutron star in a supernova explosion, and the pulsation and spin of this newborn neutron star.

♦ Starquakes (analogs of earthquakes) in neutron stars, and details of how such starquakes change the star's shape and spin.

♦ Gravitational waves produced at the moment when space and time came into being in the Big Bang creation of the universe.

♦ Discoveries of which astronomers as yet have no inkling.

What does a gravitational wave observatory look like?

The larger the gravitational-wave detector, the more sensitive it will be. To detect the very weak waves that are predicted will require two installations, each with a 4-foot diameter vacuum pipe arranged in the shape of an L with 4-kilometer (2.5-mile) arms. Since gravitational waves penetrate the earth unimpeded, these installations need not be exposed to the sky and will be entirely buried or covered by concrete. At the vertex of the L and at the end of each of its arms will be test masses that hang from wires and are fitted with mirrors. The main building at the vertex will serve as the control center and will house vacuum equipment, lasers, and computers. Ultrastable laser beams traversing the vacuum pipes will measure the effect of gravitational waves on the test masses.

How will the detectors sense gravitational waves?

Gravitational waves are ripples in the fabric of space-time. When they enter the LIGO detector they will decrease the distance between the test masses in one arm of the L, while increasing it in the other. These changes are minute: just 10^{-16} centimeters, or one one-hundred-millionth the diameter of a hydrogen atom over the 4 kilometer length of the arm. These tiny changes can be detected by isolating the test masses from all other disturbances, such as seismic vibrations of the earth and gas molecules in the air, and by bouncing high-power laser light beams back and forth between the test masses in each arm and then interfering the two arms' beams with each other. The tiny changes in test-mass distances throw the two arms' laser beams out of phase with each other, thereby disturbing their interference and revealing the form of the passing gravitational wave.

Why are two installations necessary?

At least two detectors located at widely separated sites are essential for the unequivocal detection of gravitational waves. Local phenomena such as micro-earthquakes, acoustic noise, and laser fluctuations can cause a disturbance at one site, simulating a gravitational wave event, but such disturbances are unlikely to happen simultaneously at two widely separated sites.

How will the two installation sites be chosen?

Ideally, the sites should be separated by 1,500 to 3,000 miles. They must be flat and large enough to accommodate the 4-kilometer interferometer arms. They should be far enough from urban development to ensure that they are seismically and acoustically quiet, but still within convenient distance of housing for resident and visiting staff. Electrical power and road or rail access should be sufficiently close to allow economical construction. Soil and drainage characteristics must be suitable, and environmental-impact concerns must be addressed. Sites will be selected through a competitive, public solicitation.

What are the prospects for international collaboration?

To determine (by triangulation) the exact celestial location of many gravitational-wave sources, and to extract all the other information the waves carry, more than the two LIGO sites will be required. The American scientists must rely for full information upon an international network of observatories, to be established in a collaborative arrangement with scientists in other countries. LIGO will be a crucial component of this network. At present, there are proposals pending to establish two multi-kilometer-size observatories in Europe (British-German and French-Italian collaborations) and one in Australia.

How much will LIGO cost?

Funding for LIGO will come from the National Science Foundation. Estimated cost is about $200 million.

When will LIGO be built?

The LIGO project was approved by the National Science Board (NSB) in May 1990, and the NSB authorized site selection in October 1990. It is hoped that Congress will appropriate funds for a construction start in FY '92.

For further information, please contact Robert Finn at the Caltech Office of Public Relations: 818-356-3631