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LISTENING WITH LIGHT: LASER ACOUSTICS

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BRING ADVANCES IN NON-DESTRUCTIVE

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TESTING; SOUND MEASUREMENT & SUPPRESSION

Photography Available

Laser acoustic techniques that allow scientists to "see" sound and vibration through laser light could lead to new methods for non-destructive testing of aircraft components, noise analysis in mechanical equipment, underwater sound measurement, ocean floor mapping and other potential applications. The techniques use lasers to both generate and measure sound.

To be described February 20 at the annual meeting of the American Association for the Advancement of Science (AAAS), these optical techniques offer researchers a new tool for studying acoustics in gases, liquids and solids. Laser techniques provide important advantages over other acoustic research methods because they do not alter the acoustic phenomenon being studied and can operate in relatively harsh environments.

"We are trying to understand the physics of how sound waves are radiated," explained Dr. Yves Berthelot, assistant professor of mechanical engineering at the Georgia Institute of Technology. "We need something very accurate to measure tiny displacements without perturbing the system under investigation, and the best way to do it is through lasers."

At Georgia Tech, Berthelot and Dr. Jacek Jarzynski have developed a laser probe which will be used to study the intricate coupling between vibrations and the radiation of sound from a structure submerged under water. Preliminary tests have been carried out in air to study waves emanating from a vibrating metal beam. An understanding of that coupling could lead to improved techniques for suppressing noise in mechanical equipment.

"People have always tried to reduce the noise of equipment by reducing the vibration," he explained. "That makes a lot of sense, but sometimes you can spend a lot of money reducing vibration but not affect noise because loud sounds can be created by waves with very small displacements. It all depends on how well the vibrations couple with the fluid around the structure. The laser probe should help us determine which vibrations are primarily responsible for the radiation of sound."

The probe uses a technique called differential laser Doppler interferometry. First, a beam splitter is used to divide a laser into two beams, which are led into fiber optic cable. The cables carry the beams to the experimental location, where their paths are crossed at the precise location of the vibration under study.

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The light beams are scattered off the structure in all directions, and vibrations on the structure modulate the scattered light, causing measurable disturbances in the interference patterns which normally result from crossing the beams. By analyzing those disturbances, Berthelot can obtain information about the waves.

Measuring sound waves in water is based on a similar technique. Instead of being scattered by a vibrating structure, however, the light is scattered by microscopic particles in water which oscillate in the presence of sound waves. These moving particles scatter the laser beams, and that scattered light can be picked up by a photodiode. Because the sound waves are moving, they cause a Doppler shift in the scattered light, and that shift can be analyzed to gain information about the sound waves.

Using this strategy, researchers at Georgia Tech are working on a detection system that could replace hydrophones for laboratory measurement of underwater sound.

Another use for lasers in acoustics is in the contactless generation and detection of ultrasound to inspect materials for defects. Berthelot and Jarzynski have used an array of optical fibers to guide the laser light over the surface of a material, generating sound waves which move through the material in a narrow sound beam. This sound beam can be used to generate a detailed picture of interior of the material.

For non-destructive testing of aircraft components or other critical material, such a sound beam is generated on one side of a part under examination. A laser Doppler system on the other side analyzes disturbances in the sound field which may indicate internal defects.

Because they are carried in fiber optic cables, the laser beams can be snaked into nearly inaccessible areas, offering advantages over traditional bulky ultrasound transducers. And unlike standard ultrasonic transducers, they are virtually unaffected by high temperatures or radioactivity, allowing their use in harsh environments.

Another area of research is the generation of sound in the ocean from airborne high power lasers scanning above the ocean surface. A pulsed laser would send a beam into the water, where it would cause a slight heating and expansion of the water. This thermoacoustic process would create sound waves which might be used to locate underwater objects or to map the ocean floor. Berthelot's research in this area consists of finding more efficient ways to generate thermoacoustic waves.

The laser acoustics work at Georgia Tech is sponsored by the National Science Foundation and the U. S. Office of Naval Research (ONR).

EDITOR'S NOTE: This presentation will be part of "Current Topics in Physical Acoustics," held February 20 as part of the Physics, Astronomy and Engineering Section of the AAAS meeting. For assistance during the AAAS meeting, John Toon may be contacted at the New Orleans Hilton.