Sound bullets in water

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Sound waves are commonly used in applications ranging from ultrasound imaging to hyperthermia therapy, in which high temperatures are induced, for example, in tumors to destroy them. In 2010, researchers at Caltech led by Chiara Daraio, a professor of aeronautics and applied physics, developed a nonlinear acoustic lens that can focus high-amplitude pressure pulses into compact "sound bullets." In that initial work, the scientists demonstrated how sound bullets form in solids. Now, they have done themselves one better, creating a device that can form and control those bullets in water.

The nonlinear acoustic lens is constructed from chains strung with stainless-steel spheres that are oriented parallel to one another—and squeezed together—to form an array. The gadget was inspired by Newton's cradle, a popular toy that consists of a line of identical balls suspended by wires from a frame. When an end ball is pulled back and released, it slams into the next ball, causing the last ball in the line to fly outward. Similarly, in the acoustic lens, striking one end of the array generates compact nonlinear pulses of sound—solitary waves that propagate through the lens and can be tightly focused on a target area; when they coalesce at this focal point, they produce a significantly amplified version: the sound bullet. These intense pressure waves may be used to obliterate tumors or kidney stones—leaving surrounding tissues unharmed—or probe objects like ship hulls or bridges for unseen defects.

In the new work, the lens has been made more accurate, and a waterproof interface, which efficiently transmitted the pulses, was inserted between the chains and water. "We use water as a target medium with the idea that the acoustic lens could be used for underwater imaging and/or biomedical applications," says postdoc Carly Donahue, who helped refine the device.

"Currently, our work is fundamental in nature. We are focused on demonstrating proof of principle and establishing the technical strengths and weaknesses, which will inform the future design of engineering devices for specific applications," she adds. "For example, using these systems in biomedical applications requires reducing their dimensions and learning about the related scaling effects. Creating commercially viable devices will require the involvement of industrial partners."

More information: Donahue discusses the technology and its potential applications in a talk at the APS Division of Fluid Dynamics Meeting, which will take place November 18-20, 2012 at the San Diego Convention Center, located near the historic Gaslamp District on the waterfront, in San Diego, California. The talk, "An Experimental Study of a Nonlinear Acoustic Lens Interfaced with Water," is at 4:45 pm on Sunday, November 18, 2012, in Room 30E.
meeting.aps.org/Meeting/DFD12/APS_epitome

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