Sound bullets could treat cancers and replace ultrasound (w/ Video)

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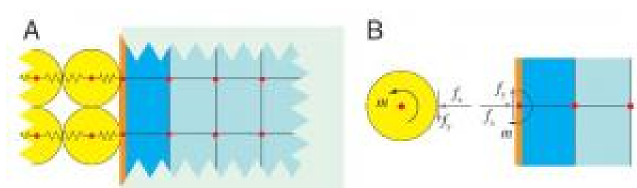
Newton's cradle

(PhysOrg.com) -- Acoustic devices are used in a range of applications such as ultrasound scanners, but their performance is limited for some uses by their inaccurate focusing and low focal power. Now a group of scientists in the US have developed an acoustic lens that can focus acoustic waves with greater energy than ever before possible to produce "sound bullets" that could find many uses, including effective, nonintrusive sonic scalpels for destroying tumors or kidney stones.

Researchers, Alessandro Spadoni, from Graduate Aerospace

Laboratories, and Chiara Daraio of Applied Physics, at the California Institute of Technology, at Pasadena, California, designed the new acoustic lens for use in medical applications. The high pressure induced by the compact acoustic pulses, or sound bullets, causes the temperature at the focal point to rise, so the bullets could be used to burn tissue without affecting surrounding tissues. If modulated differently, it could also be used to produce near photo-quality images of the inside of the body, but without the radiation risks of X-rays.

The new acoustic lens is made of a metamaterial and uses the Newton's cradle principle, which is familiar to many people from a toy with identical metal balls suspended on strings, designed to demonstrate the conservation of energy. When the ball at one end is pulled out and released, the ball at the other end swings out at the same speed. The metamaterial comprises 21 parallel chains, each containing 21 stainless steel spheres, but instead of channeling motion, the balls channel sound waves, which are converted to a shock wave called a "solitary wave". The energy leaving the lens does not bounce back through the chains because of the length of the chains, and instead is focused on a spot a few centimeters in front of it.



Combined DP/FE model. (A) Arrays of spheres interact with a baffle (orange lines) which in turn interacts with the adjacent fluid. (B) The interaction of granular media and baffle. Image: Spadoni et al. 10.1073/pnas.1001514107

Professor Daraio said the conversion of sound to a solitary wave is essential because solitary waves are easier to control than sound, and enabled them to achieve high focal intensities in the sound wave emitted, and its position could be controlled without needing to change the lens structure. Daraio said that if the outer chains are squeezed together closer than the inner chains, the solitary waves travel faster in the outer chains, resulting in successive sound pulses. The scientists can also adjust the intensity of the sound bullets emitted, so they can be powerful enough to be used as sonic scalpels or gentle enough for internal body imaging. The latter use would be an improvement on ultrasound because the sound is more highly focused, and can be repositioned easily.

The system is still under development and has not yet been tested on living cells. It is likely to be some years before it is available for medical or other applications.

The research paper is published in this week's issue of the *Proceedings of the National Academy of Sciences* journal.

More information: Alessandro Spadoni and Chiara Daraiob, Generation and control of sound bullets with a nonlinear acoustic lens, Published online before print April 5, 2010, doi:10.1073/pnas.1001514107

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