Acoustic Levitation using Metamaterials

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Background
Scientists have been levitating using standing waves since the 1980s. However single sided levitation (i.e. using only one array of transducers without a reflector) was first achieved in 2015 using electronics to alter the phase delay of each transducer creating an acoustic trap. There are three types of optimum single-beam traps: Twin, Vortex and Bottle. The most reliable one is the twin trap (tweezer like trap) in which a focus is created and then a π-phase shift is applied to the transducers on one half of the array resulting in two foci canceling each other in the middle creating the trap.

Metamaterials can be defined as engineered pieces of material that vary the phase of sound propagating through them depending on the design.

Objective
- Controlling the phase shift using electronics allows one to move the trap around; therefore enabling the manipulation of a particle without the aid of any physical movement. However the downside of using electronics is that they are complicated and expensive.
- Here we supply only one signal (40kHz) to all the transducers and the phase delays are achieved using the metamaterial.

Design of Metamaterial
- The metamaterial was designed to have coil-like paths.
- The phase delays were obtained by fixing the height and altering the number of revolutions of the coil; therefore changing the paths length.
- A horn was fitted at both ends of the path to minimize the attenuation caused by the sudden change in diameter and to keep the directivity pattern as the original transducer.

Advantages of Metamaterials for Levitation
- Simpler and cheaper for mass production
- Allows the use of a single transducer to levitate.
- Using metamaterials might be one of the easiest ways to achieve 3D levitation in water.

Note: levitation in water is a step closer towards manipulation of particles inside the human body.

References