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Title: Stackable acoustic holograms

Background, Motivation and Objective

Acoustic holograms are objects that can be used to generate complex acoustic patterns from single element transducers. They are 3D printed lenses that map the transducer field onto a pre-calculated phase hologram via variations in thickness. One drawback of this approach, however, is that the pattern is fixed. This can be partially circumvented by exploiting the chromatic properties of these lenses. These allow the pattern to be scaled or for distinct patterns to be generated at different driving frequencies, however, the relative orientations are still fixed.

To overcome this another property of these lenses can be used. That is the field transmitted by the lens contains several components: a diffracted wave which creates the pattern, an un-diffracted (plane) wave, and higher diffraction orders. The energy in each is determined by the phase delay introduced by the lens. By controlling this, multiple lenses can, in principle, be combined or stacked and independently moved without perturbing each other's field. The goal of this work was to validate this idea.

Statement of Contribution/Methods

First, the energy coupled into each wave component as a function of phase delay was evaluated numerically. Lenses were then designed using an iterative Fourier transform algorithm and subsequently scaled to couple the desired energy into each wave component. The k-Wave toolbox was used to simulate the output field generated by multiple lenses when combined and to investigate the effect of transducer shape, and lens number on the field.

Lenses were then fabricated via 3-D printing and placed in front of a planar single element transducer. The field generated by each different combination of lenses was characterised experimentally. Changes to the field created by translating different lenses were also measured.

Results/Discussion

Both the simulated and experimental results demonstrated that by scaling the lens phase delay, multiple lenses (each creating a distinct pattern) can be combined, swapped, and repositioned. This is illustrated in the attached image which shows a set of simulations that demonstrate both alteration of a pattern by lens swapping and translation of one pattern relative to another by lens movement.

This result could be useful in many areas of physical acoustics. For example, for particle manipulation the spacing between a set of objects could be flexibility changed.