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A time reversal metasurface for mimicking the cocktail party effect

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The cocktail party effect is the capability to focus one's auditory attention on particular audio sources while ignoring other audio sources. We propose an experimental setup reproducing the cocktail party effect by designing a time dependent metasurface composed of independent active mirrors. Each active mirror is a programmable acoustical unit cell capable of hearing, computing and emitting acoustic signals: each of them acts as a convolution filter. The proper metasurface temporal filters configuration allows us to establish acoustic communication between groups of individuals immersed in a noisy environment: we have designed a multi-user, multi-input and multi-output (MU-MIMO) acoustic system.

The experiment based on underwater ultrasonics consists in prerecording a set of Green's function between N_e emitters and N_j active mirrors, and a second set Green's functions between the N_j active mirrors and N_r receivers. In order to increase the spatio-temporal degrees of freedom (Lemoult et al., PRL 103 (2009)), we place a forest of steel rods in between the active mirrors and both the emitters and the receivers. These data are then used to compute each active mirror's temporal filter using time reversal properties to establish a proper predefined MU-MIMO configuration. The N_e emitters now emits simultaneously uncorrelated noises, hence reproducing the cocktail party situation. These signals propagate through the disordered medium to the metasurface, then each active mirror of the metasurface hears, convolutes with his temporal filter and emits another signal which propagates back through the disordered medium towards the N_r receivers. In the end we establish a correlation matrix by comparing emitted and received signals and we demonstrate how the time reversal based metasurface allows to focus signals coming from specific emitters towards their dedicated receivers.

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