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Wavefront shaping in complex media for analog computation

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Performing linear operations using optical devices is a crucial building block in many fields ranging from telecommunications to optical analogue computation and machine learning. For many of these applications, key requirements are robustness to fabrication inaccuracies, reconfigurability and scalability.
Traditionally, the conformation or the structure of the medium is optimized in order to perform a given desired operation.
Since the advent of wavefront shaping, we know that the complexity of a given operation can be shifted toward the engineering of the wavefront, allowing, for example, to use any random medium as a lens.
We propose to use this approach to use complex optical media such as multimode fibers or scattering media as a computational platform driven by wavefront shaping to perform analogue linear operations. Given a large random transmission matrix representing the light propagation in such a medium, we can extract any desired smaller linear operator by finding suitable input and output projectors. We demonstrate this concept by finding input wavefronts using a Spatial Light Modulator that cause the complex medium to act as a desired complex-valued linear operator on the optical field.