From Opaque to Transparent: Control of Light Scattering by Gain and Loss

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Abstract: Because of multiple scattering, light hardly penetrates a one-dimensional (1D) disordered system. Intensity distribution decreases exponentially, on a characteristic distance, ξ, called the localization length. We first explore the nature of the modes when ξ is smaller than the length of the system. By introducing gain and shaping its spatial profile along the 1D scattering medium, we select these modes, and show that they are spatially localized and serve as optical distributed cavities for single-mode random lasing.

We then design a 1D photonic device including a random laser followed by an active scattering medium where gain shaping is used below lasing threshold to control light amplification. We demonstrate that a subtle but complex distribution of gain and loss can turn an opaque medium into an optically transparent piece of material. This confirms recent theoretical predictions by the group of S. Rotter [Makris *et al*. Light Sci. Appl. 6, e17035 (2017)], which show that, in a non-Hermitian system with any given distribution of refractive index, one can find a suitable distribution of the imaginary part of the refractive index, such that a wave will traverse freely the scattering medium without any backscattering or intensity variation along the sample.