Towards Anderson localization of light in three dimensions

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Theoretical research suggests that longitudinal electromagnetic fields impede Anderson localization of light in three-dimensional (3D) ensembles of resonant scatterers, including cold atoms and dielectric particles. We propose to look for Anderson localization of light in porous conducting (i.e., metallic) structures where longitudinal fields are suppressed [1]. Our numerical results demonstrate that indeed, transmission of light through such structures mays exhibit signatures expected for Anderson localization: non-exponential decay of the time-dependent transmission, arrested expansion of the diffusive halo, enhanced fluctuations in the spectrum of light, etc. We study the behavior of light in these structures as a function of its frequency and identify the critical frequency (also called the mobility edge) below which the “normal” diffusive behavior changes into the one expected for Anderson localization [2]. Finite-size scaling analysis allows for estimating the critical exponent of the discovered localization transition, which turns out to be consistent with the value expected for the orthogonal universality class (the same class as for spinless electrons in the presence of time-reversal symmetry). Our results pave the way towards experimental observation of Anderson localization of light in 3D.

1. A. Yamilov, S.E. Skipetrov, T.W. Hughes, M. Minkov, Z. Yu, & H. Cao, Anderson localization of electromagnetic waves in three dimensions, *Nature Physics* **19**, 1308 (2023)
2. A. Yamilov, H. Cao & S.E. Skipetrov, Anderson transition for light in three dimensions, arXiv:2408.04853