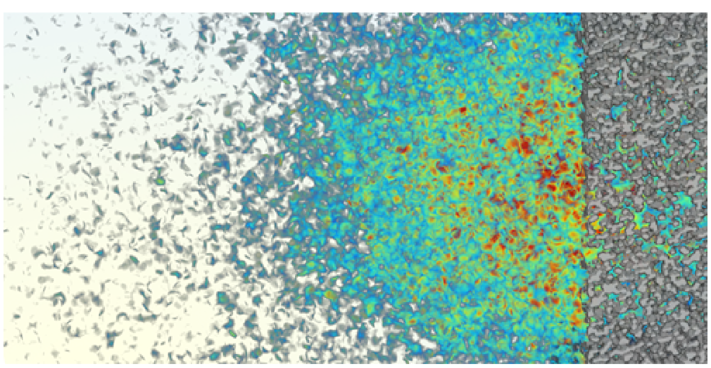
Localizing Light

Simulations demonstrate that light can be confined within a scattering medium in a way similar to electrons in a disordered metal.

By **Charles Day**

Conduction electrons diffuse freely through a pure metal. But if a metal's disorder crosses a certain threshold, the electrons become trapped. This so-called Anderson localization arises from interference between the electrons' paths. Light, being wave-like, could also experience Anderson localization. Proving that it does so has eluded experimenters and theorists alike. Two years ago, Alexey Yamilov of the Missouri University of Science and Technology and his collaborators used computer simulations to demonstrate that light can indeed be confined within a disordered medium [**1**]. Now they have shown that the transition to localization is Andersonian [**2**].

One challenge to localizing light turned out to be its transverse electric field, which induces longitudinal electric fields in a dielectric medium. If the medium is disordered, the two types of fields couple to create transport channels that carry energy away and forestall localization. In their 2023 simulations, Yamilov and his collaborators did not find localization in a dielectric medium no matter how disordered it was. But they did find that light could be localized in a disordered medium consisting of perfectly conducting spheres suspended in air, where the longitudinal fields are absent.



Credit: A. Yamilov/Missouri S&T

Their new and more extensive set of simulations explored the transition from the diffusive regime to the localized regime. For a given set of parameters, the transition occurred when the light had a critical frequency ω_c. As the frequency ω approached ω_c, the localization length—that is, the characteristic size of the trapped states—diverged in proportion to $|\omega - \omega_c|^{-\nu}$. The value of ν that the researchers derived is consistent with Anderson localization observed with other kinds of waves. As for localizing light in a real medium, Yamilov points out that a metallic sponge-like material could conceivably trap microwaves.

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REFERENCES

1. A. Yamilov *et al.*, "Anderson localization of electromagnetic waves in three dimensions," **Nat. Phys. 19 (2023).**
2. A. Yamilov *et al.*, "Anderson transition for light in a three-dimensional random medium," **Phys. Rev. Lett. 134, 046302 (2025).**