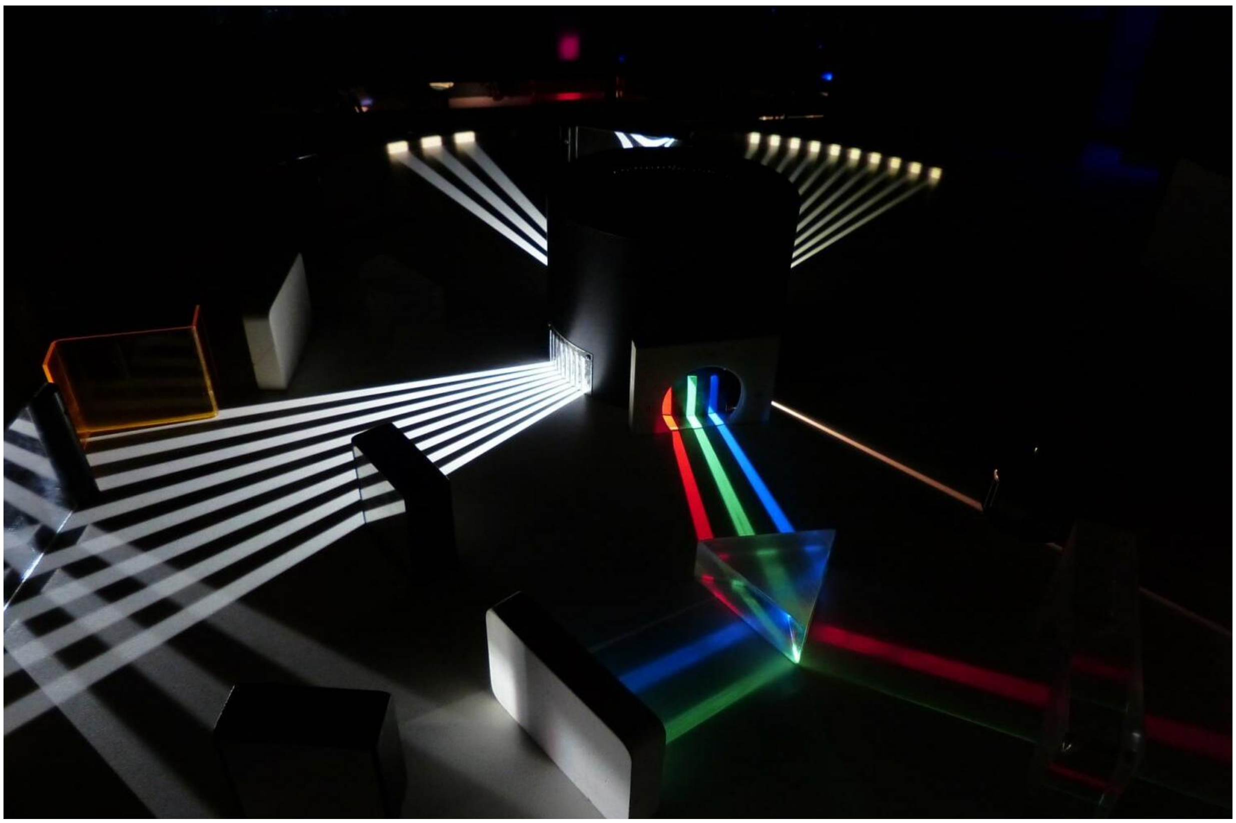
Semi-random scattering of light

November 17 2020



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What is the exact path of light inside a highly scattering material like white paint? This is a question that is impossible to answer, as the particles inside the paint are distributed randomly. This, at the same time, is a very attractive property for applying photonics in non-hackable security applications. Still, you would like to have a look inside to see what is happening. For this reason, researchers of the University of Twente (MESA+ Institute), built a light-scattering microcube that is both random and controlled. Contradictory as it seems, this is a way to know exactly what is happening inside. The research results are in *Advanced Optical Materials*.

Earlier research by UT researchers demonstrated the way light can be controlled, even when it travels through randomly scattering media like white paint. This might lead to a credit card that can't be hacked, or new medical imaging applications. In brief: Researchers know how light falls on the surfaces, and can even predict how it gets out. But the path it travels in between is unknown. Why not reverse the question, the UT scientists thought: Let's create a structure that we know precisely and that is random at the same time. In practice: let's make a tiny cube with hundreds of nanorods inside. Although they seem organized in full randomness, you know exactly where these rods are, and thus where the light is, at any given moment.

Micro-sized turkish sweet

This is done using a precision 3-D printing technology called direct laser writing, available at UT's MESA+ NanoLab. The nanorods are written using a laser and a special gel material. After hardening, the material in between is washed away. A sponge-like cube remains. The size of the cube is 15 x 15 x 15 microns, for example, with 400 to 2000 nanorods inside. The question is: What part of the incident light comes out, and in what way is this influenced by the number of rods? For a lower number of rods—less randomness—more light travels straight through the material and exits at the location you would expect. For higher numbers, light also exits at other locations, the research shows.

In their earlier publication, using a classic mathematics paradox, the UT researchers demonstrated how these rods should be organized to obtain a homogeneous distribution across the whole cube. This is a manufacturing challenge, as well: Even if the structure looks great from the outside, there may be a lump of hardened polymer at the center of the cube that fully overrides the desired effects. Images using special X-Ray microscopy, available in Grenoble, show that the entire cube consists of the expected rods.

This research gives more insight into scattering light inside randomly organized materials. It helps define the boundary conditions for applications in information security or imaging," says research leader Pepijn Pinkse of the Complex Photonic Systems group, part of UT's MESA+ Institute for Nanotechnology.

The paper, "Deterministic and Controllable Photonic Scattering Media via Direct Laser Writing," is published online in *Advanced Optical Materials*.

More information: Evangelos Marakis et al. Deterministic and Controllable Photonic Scattering Media via Direct Laser Writing, *Advanced Optical Materials* (2020). DOI: 10.1002/adom.202001438

Provided by University of Twente