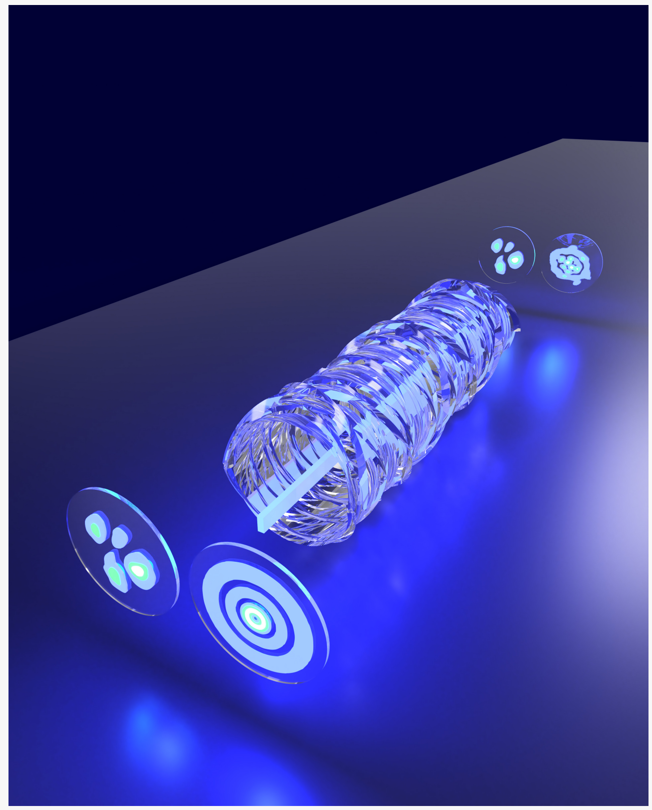
Researchers find distortion-free forms of structured light

Research offers a new approach to studying complex light in complex systems.



When light passes through a noisy channel such as the atmosphere, it gets distorted, but there exist complex forms of light that come out distortion-free, so that the output pattern is the same as the input.

JOHANNESBURG, GAUTENG, SOUTH AFRICA, February 9, 2023 /EINPresswire.com/ -- An exciting prospect in modern optics is to exploit “patterns of light”, how the light looks in its many degrees of freedom, often referred to as structured light.

Each pattern could form an encoding alphabet for optical communication or might be used in manufacturing to enhance performance and productivity. Unfortunately, patterns of light get distorted when they pass through noisy channels, for instance, stressed optical fiber, aberrated optics, turbid living tissue, and perhaps a very severe example, atmospheric turbulence in air.

In all these examples, the distorted pattern can deteriorate to the point that the output pattern looks nothing like the input, negating the benefit. Now researchers from the University of the Witwatersrand (Wits University) in South Africa have shown how it is possible to find distortion-free forms of light that come out of a noisy channel exactly the same as they were put in.

Using atmospheric turbulence as an example, they showed that these special forms of light, called eigenmodes, can be found for even very complex channels, emerging undistorted, while other forms of structured light would be unrecognisable. Their research has been published in the journal, Advanced Photonics – the flagship journal of SPIE, the international society for optics and photonics.

“Passing light through the atmosphere is crucial in many applications, such as free-space optics, sensing and energy delivery, but finding how best to do this has proved challenging," says Professor Andrew Forbes, head of the Structured Light Laboratory at Wits University.

Traditionally a trial-and-error approach has been used to find the most robust forms of light to some particular noisy channel, but to date all forms of familiar structured light have shown to be distorted as the medium become progressively more noisy. The reason is that we "see" the distortion.

To establish whether it is possible to create light that doesn't "see" the distortion, passing through as if it wasn't there the researchers treated the noisy channel as a mathematical operator and asked a simple question: "what forms of light would be invariant to this operator?". In other words, what forms of light appear as the natural mode of the channel that it is in, so that it don't see the distortion. This can also be called the true eigenmodes of the channel.

The example tackled was the severe case of distortions due to atmospheric turbulence. The answer to the problem revealed unrecognizable forms of light – in other words, light that is not in any well-known structured light family, but nevertheless completely robust to the medium. This fact was confirmed experimentally and theoretically for weak and strong turbulence conditions.

"What is exciting about the work is that it opens up a new approach to studying complex light in complex systems, for instance, in transporting classical and quantum light through optical fiber, underwater channels, living tissue and other highly aberrated systems," says Forbes.

Because of the nature of eigenmodes, it doesn't matter how long this medium is, nor how strong the perturbation, so that it should work well even in regimes where traditional corrective procedures, such as adaptive optics, fail.

"Maintaining the integrity of structured light in complex media will pave the way to future work in imaging and communicating through noisy channels, particularly relevant when the structured forms of light are fragile quantum states."

Professor Andrew Forbes
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email us here
