Topological photonics in fractal lattices

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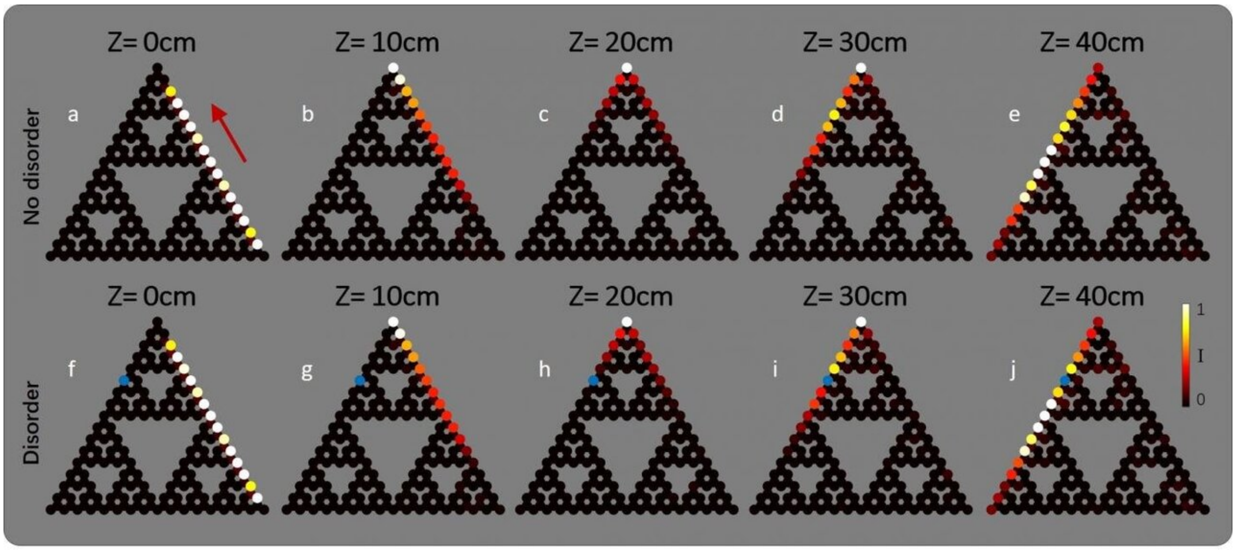

a-e Evolution of topological edge states in the fractal SG(4) lattice. a Intensity distribution of the initial field constructed from a truncated topological edge state in the fractal lattice. b-e Intensity distribution at propagation distances . f-j Evolution in the fractal lattice containing on-site disorder of , whose position is marked by the blue dot. The wavepacket displays topologically-protected edge transport around the corners and is unaffected by the disorder. The color bar indicates the field intensity. Credit: by Zhaoju Yang, Eran Lustig, Yaakov Lumer and Mordechai Segev

Topological insulators are a new phase of matter unique for their insulating bulk and perfectly conducting edges. They have been at the forefront of condensed matter physics for the past decade, and more recently inspired the emergence of topological phases in many classicalwave systems, such as photonics and acoustics. To date, all studies of topological insulators have explored systems in integer dimensions (physically, 2-D or 3-D) with a well-defined bulk and edges. However, physical dimensions do not always define the dimensions in which a system evolves: Some structures have a noninteger (fractal) dimension, despite being in a 2-D or 3-D realm.

In a new paper published in *Light Science & Applications*, a team of scientists, led by Professor Mordechai Segev from the Physics Department and Solid State Institute, Technion-Israel Institute of Technology, Israel, and co-workers have developed the photonic Floquet topological insulator in a periodically driven fractal lattice. This lattice relies on a fractal photonic crystal [the Sierpinski gasket (SG)] consisting of evanescently coupled helical waveguides, which can be realized by femtosecond-laser-writing technology. They calculate the topological Floquet spectrum and show the existence of topological edge states corresponding to real-space Chern number 1. The simulations of the edge states show that wavepackets made up of topological edge states can propagate along the outer and inner edges without penetration into the 'bulk' and without backscattering even in the presence of disorder and sharp corners.

"Our results suggest a wealth of new kinds of topological systems and new applications, such as using topological robustness combined with the enhanced sensitivity of fractal systems for sensing and, in non-Hermitian settings, topological insulator lasers in fractal dimensions," the scientists forecast.

More information: Zhaoju Yang et al, Photonic Floquet topological insulators in a fractal lattice, *Light: Science & Applications* (2020). DOI: 10.1038/s41377-020-00354-z