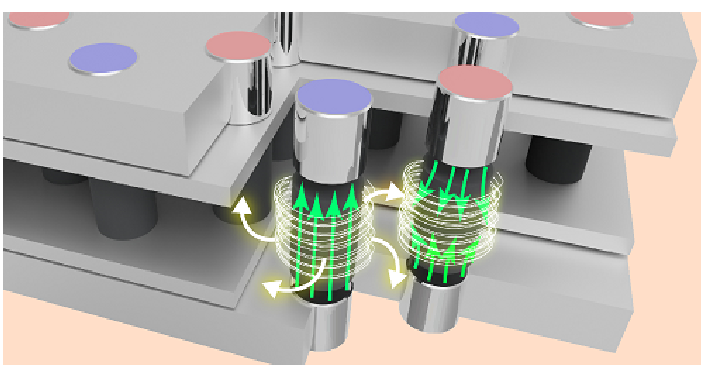
Enter the Photonic Chern Semimetal

A two-dimensional photonic metamaterial combines useful features of two quantum materials.

By Ryan Wilkinson

Among the crystalline materials whose edges host exotic quantum states are the Dirac semimetal and the Chern insulator. In the semimetal, the edge states are localized and not protected from perturbations by their topology; in the insulator, they move in one direction and are protected. Proposed by theorists in 2011, a hybrid phase called a Chern semimetal simultaneously hosts localized and one-way edge states, both with topological protection (see **Synopsis: Quantum Hall Anomaly in 3D**). Now Jianfeng Chen and Cheng-Wei Qiu at the National University of Singapore and their colleagues have realized this phase in a two-dimensional photonic metamaterial [**1**]. The researchers say that their system provides a platform for nanophotonic applications and a playground for topological physics.

The researchers built a honeycomb-shaped, single-layer array of millimeter-sized magnetic rods. They then applied a carefully tuned, spatially varying magnetic field to this array, creating a pattern in which only specific rods were magnetized. Lastly, they placed a source of microwaves at the array's boundary and observed how the microwave radiation traveled through the structure. The team found that the magnetization pattern caused some radiation to localize at the array's boundary and other radiation to move in one direction around the boundary. All these edge states were topologically protected in that they were immune to scattering caused by slight differences in the alignment, shape, and size of the rods and other material imperfections.



Credit: J. Chen *et al.* [**1**]

Thanks to the coexistence and potential hybridization of localized and one-way states, a photonic Chern semimetal can reduce the speed of transmitted radiation. The researchers found that their metamaterial exhibited a slowdown factor of up to 30 while preserving the radiation's topological protection. They say that this capability could be useful for nanophotonic technology.

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REFERENCES

1. J. Chen *et al.*, "Chern-protected flatband edge state in metaphotonics," **Phys. Rev. Lett. 134, 223806 (2025).**