Realization of a three-dimensional photonic topological insulator

With the support by the National Natural Science Foundation of China and Zhejiang University, the research team led by Prof. Chen HongSheng (陈红胜) at Zhejiang University in China, and their co-workers, the Singapore research team led by Prof. Baile Zhang and Prof. Yidong Chong, experimentally realized a three-dimensional photonic topological insulator, which was published in *Nature* (2019, 565: 622).

Confining photons in a finite volume is highly pursued in modern photonic devices. Recently, inspired by the discovery of exotic quantum states known as topological insulators (TIs) in the condensed-matter physics, the emerging field of topological photonics has revolutionized the traditional views on light propagation and manipulation, opening an avenue towards the discovery of fundamentally new states of light and possible revolutionary applications. However, all experimental realizations of classical analogues of TIs have thus far been limited to two-dimensional (2D).

To extend the concept of photonic TI from 2D to 3D, one proposal is finding a bi-anisotropic (magneto-electric coupling) material that possesses big photonic band gaps. Based on the research of metamaterial, Prof. Chen's group design a splitring resonator structure (a class of classic electromagnetic artificial atoms, or "meta-atoms") with strong magneto-electric coupling. Using direct near-field imaging measurements, they map out both the gapped bulk band structure and the Dirac-like dispersion of the surface states, which is the key of a 3D photonic TI. These surface states behave the robust propagation along a sharply bent surface, confirming the topological protection.

This experimental work revealed in the *Nature* paper extends the family of 3D TIs from fermions to bosons and paves the way for many unprecedented opportunities in photonics applications such as topological photonic cavities, circuits, and lasers in previously inaccessible 3D geometry. It may extend to other bosonic systems, such as phononic (acoustic/mechanical) structures and cold-atom systems, and thereby offer unprecedented possibilities for controlling waves in 3D geometries.

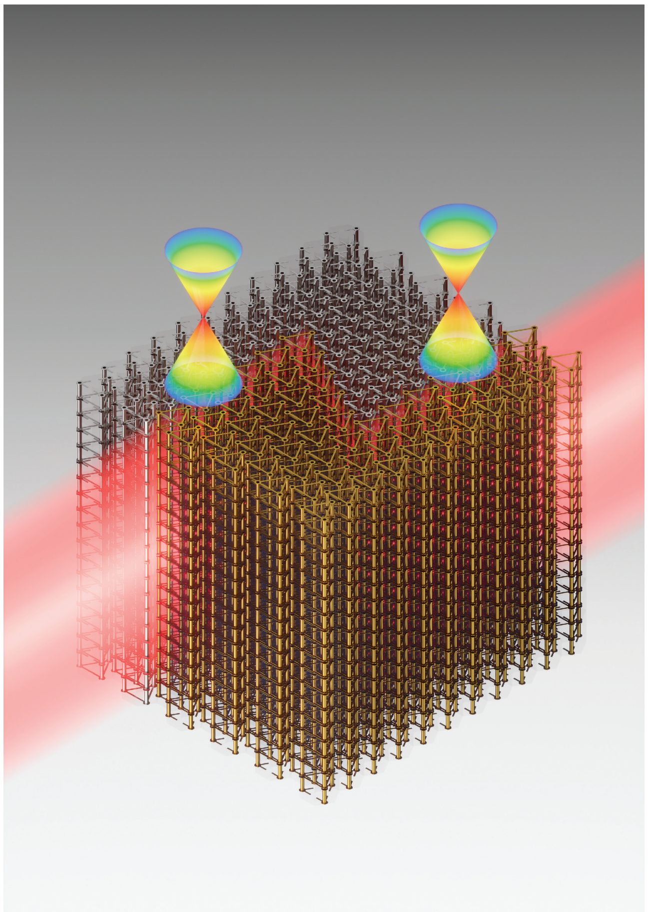

Figure Dirac-like surface states propagate through the sharp bents.