Higher-Order Topological Insulators in Metamaterials

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Higher-order topological insulators (HOTIs) can support boundary states at least two dimensions lower than the bulk, attracting intensive attention from both fundamental science and application sides. Lattice-based tight-binding models such as Benalcazar-Bernevig-Hughes model have driven significant advancements in realizing HOTIs across various physical systems. Here, beyond lattice model, we demonstrate that a cylinder with an arbitrary cross section, composed of a homogeneous electromagnetic medium featuring nontrivial second Chern numbers $c_2 = \pm 1$ in a synthetic five-dimensional space, can exhibit topologically protected HOTI-type hinge states in three-dimensional laboratory space. Interestingly, this hinge state is essentially a chiral zero mode arising from the interaction between Weyl arc surface states, guaranteed by a nontrivial c_2, and an effective magnetic field induced by the curvature of the cylinder surface. Compared to conventional schemes to generate HOTIs, our approach is more robust as it does not require additional symmetry protections such as $\mathcal{T}P$ or chiral symmetry. We experimentally realize such a cylinder using a photonic metamaterial and confirm the existence of hinge states via microwave near-field measurements. Our work introduces the concept of boundary gauge fields and establishes the link between synthetic-space c_2 and real space HOTI states, thereby generalizing HOTIs to corner-less systems.

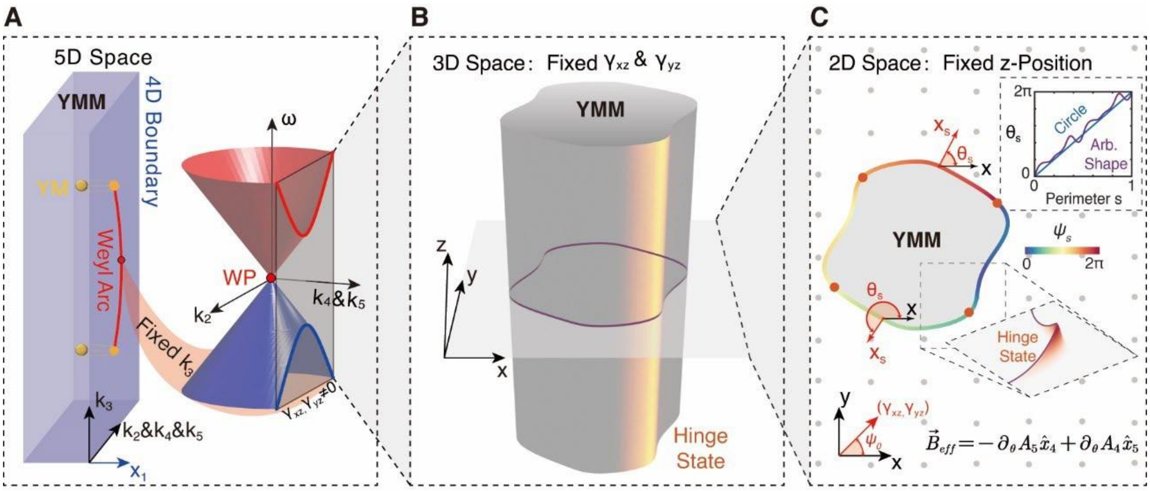

Fig. 1 Illustration of the HOTI-type Hinge States in an arbitrary YMM Cylinder.

References

1. S. Ma, H. Jia, Y. Bi, S. Ning, F. Guan, H. Liu, C. Wang, S. Zhang, Physical Review Letters, **130**, 243801 (2023)
2. Boundary Gauge Field-Induced Topological Hinge States in Photonic Metamaterials, https://doi.org/10.21203/rs.3.rs-5821179/v1