Topological n-root Su–Schrieffer–Heeger models in photonic ring systems

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Square-root topology and its extensions to roots of order 2^n have recently appeared in the field of topological insulators. Essentially, they exploit the relationship between the root and parent Hamiltonians via a power operation. Several interesting effects appear in the root systems, such as an increased amount of energy bandgaps and an inheritance of the topological protection of the parent.

We have gone one step further by developing the framework for designing general n-root topological insulators -for any positive integer n- and demonstrating the method using the SSH model as the parent system. To obtain the n-root system, one must generate an n-partite lattice, which we accomplished by employing loops of unidirectional couplings that make the system non-Hermitian. This coupling structure bestows the system with a generalized chiral symmetry, causing n separate and identical branches to appear in the complex energy-band spectrum. In each branch, n edge states appear within a ring gap on the complex plane – a novel type of gap that cannot be reduced to point or line gaps. For the implementation, we propose to employ a lattice of ring resonators coupled through antiresonant link rings. To achieve unidirectionality, the link rings feature a split gain–loss distribution, enhancing coupling in one direction while suppressing it in the other. We analyze the cubic root of the SSH model, including a detailed description of its symmetries, its topological characterization, and a comparison of its robustness against disorder with that of the parent model. Finally, we generalize the root method to arbitrary order n by extending the coupling-loop length through additional sites in the unit cell. We also describe in detail the implementation in ring resonators and present simulations for the roots of order 3, 4 and 5.

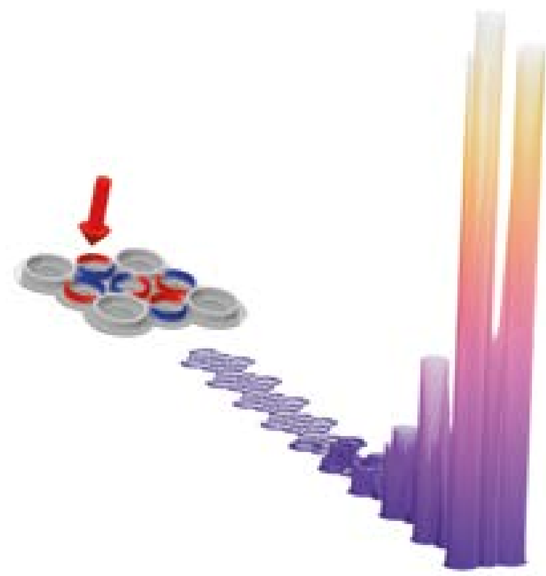

FIGURE 1
Unit cell showing asymmetric couplings via link rings with gain/loss modulation and an edge state localized at one end of the lattice.

Reference

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