Topology of light polarization vortices in nanophotonic crystals

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Abstract

The simulation of topological modes offers an important prospect for realizing robust phenomena that are not affected by the external environment. In photonic crystals, this robustness can manifest through the emission of vortex beams with a non-trivial topological charge. Bound states in the continuum (BICs) emerge as light polarization vortices in nanophotonic systems and have extremely high Q factors and low radiation losses. We show that these BIC modes allow lasing emission with non-trivial polarization properties akin to vortex beams. By combining group theory with a careful design of the lattice, we further demonstrate that different BICs with distinct topological charges can lase in various regimes, while our simulations confirm that the modes' quality factors undergo a loss-induced topological transition as the scale of the unit cell changes. We then explore the relation between the symmetry of the photonic structure and the rotationality of the vortex, experimentally demonstrating high topological charges in quasicrystals. By developing an effective non-Hermitian model, we offer insights into the topology of the far-field emission and how it is connected to the standard band topology in the presence of BICs.

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