Topological Corner States of Hexagonal Photonic Crystals with Broken Inversion Symmetry

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The application of mathematical concept “topology” to solid state physics has brought an important breakthrough in designing new functional materials and devices. This idea is also applied for photonic crystals (PhCs), where dielectric media are placed periodically and electromagnetic (EM) wave in PhCs is well described by Bloch functions similar to the electrons in a solid crystal [1]. The study of topological PhCs has promised a wide range of applications in transformative technology.

In this work, the topological states of two-dimensional (2D) hexagonal PhCs in absence of inversion symmetry (IS) are studied using the plane wave expansion method, where the periodic functions of EM waves are used for the evaluation of photonic band structures and Berry curvature (BC) distribution in the momentum space. Our research findings indicate that the broken IS leads to the appearance of non-equivalent valley degree of freedom, resulting in the localization of EM wave at one-dimensional edges or zero-dimensional corners. The results suggest a promising platform of future application of valley PhCs and provide the possibility to the application of topological PhCs in communication using valley degree of freedoms.

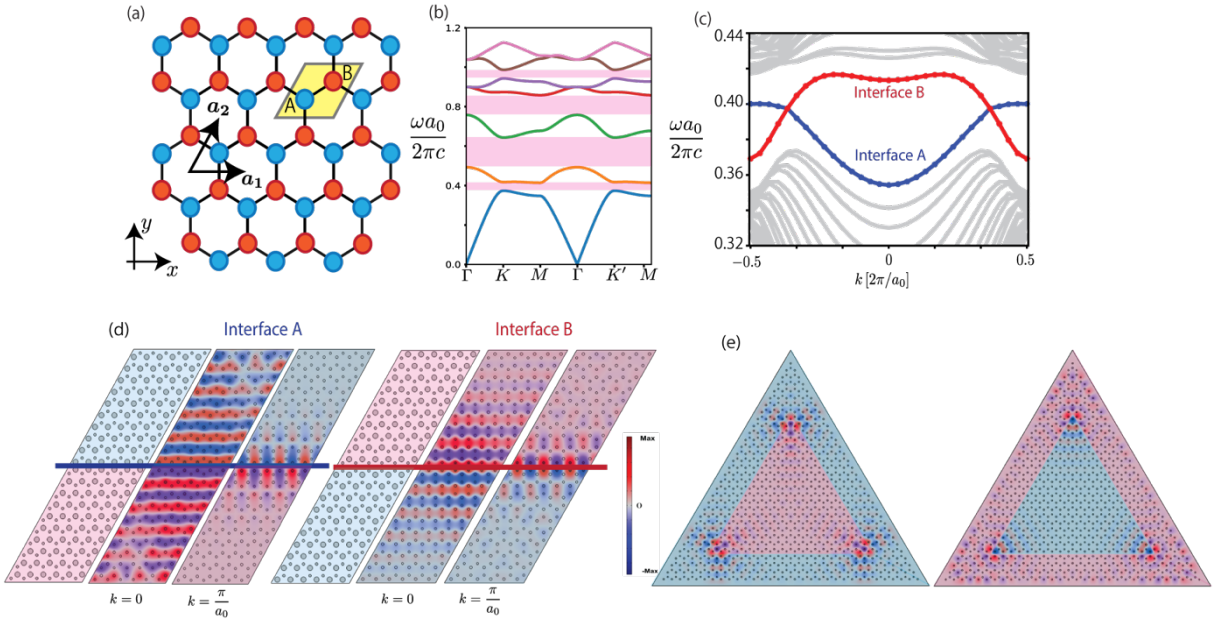

FIG. 1. (a) 2D hexagonal PhC structure with broken IS. There are two kinds of rod indicated as cyan and magenta circles. The solid rhombus is unit cell. (b) Photonic band structure for $r_A = 0.0825a_0$, $r_B = 0.1a_0$, $\varepsilon_A = \varepsilon_B = 15$, showing several band gaps. (c) Photonic band structure of zigzag interface. Blue and red dot lines are interface A and interface B, respectively. (d) Field profile for 2 types of topological interface states. (e) Field profile for 2 types of topological corner states.

Reference

[1] S. Raghu and F. D. M. Haldane, *Phys. Rev. A* 78 033834 (2008).