Bragg and Valley Hall Phononic Crystals: Comparing Approaches to Wave Propagation Control

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Abstract

Selective valley–momentum coupling and the realization of directional valley transport with strong immunity to backscattering remain central challenges in valleytronics. Here, we propose a silicon-based structure composed of connected triangular elements arranged within a rhombus unit cell. This geometry supports both trivial and non-trivial bandgaps at distinct spectral frequencies. We investigate two types of interfaces between lattices with opposite valley Chern numbers: an *abrupt interface*, characterized by an atomically sharp domain wall, and an *adiabatic interface*, where the Chern number varies gradually across the junction, enabling field modes to adapt continuously to structural changes. The adiabatic configuration exhibits remarkably low backscattering, even when guiding topological modes through a 120◦ bend. Analogous comparisons are performed for trivial modes within a Bragg-type gap, allowing a direct assessment of robustness against local defects. Our results demonstrate the superior resilience of topological valley modes compared with their trivial counterparts, establishing a viable platform for robust valley-based photonic transport.

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