Breakdown of Conventional Topological State Prediction in One-Dimensional Lattices

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Topological phononic crystals (PnCs), a special class of PnCs with unique wave manipulation capabilities, have garnered significant attention over the past decade. Drawing parallels to topological insulators (TIs) in quantum physics—where a topological invariant categorizes materials or structures based on their conductive states—mechanical systems also exhibit topological invariants. These invariants are derived from the spectral evolution of eigenvectors (or mode shapes) through unit cell analysis, determining the number and types of topologically protected domain-wall states (TPDWSs) that confine phonon modes both statically and dynamically. This relationship is commonly referred to as the bulk-edge correspondence.

In this talk, I will present theoretical and experimental evidence demonstrating that the number of TPDWSs in a mechanical Su-Schrieffer-Heeger (SSH) model can exceed the winding number prediction when beyond-nearest-neighbor interactions are considered. This reveals a breakdown in the conventional winding number framework. To address this, we employ the Berry connection to accurately characterize the number and spatial features of TPDWSs in SSH systems. Our findings are further supported by Jackiw-Rebbi theory, which confirms that multiple TPDWSs correspond to bulk Dirac cones. These insights advance our understanding of complex network dynamics and provide a generalized framework for predicting TPDWSs in applications involving localized vibrations, such as drug delivery and quantum computing.

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