
Surface impedance and topologically protected interface modes in one-dimensional phononic crystals for longitudinal and bending elastic waves

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Abstract

When semi-infinite phononic crystals (PCs) are in contact, localized modes may exist at their boundary. The central question is generally to predict their existence and to determine their stability. With the rapid expansion of the field of topological insulators, powerful tools have been developed to address these questions. In particular, when applied to one-dimensional systems with mirror symmetry, the bulk-boundary correspondence claims that the existence of interface modes is given by a topological invariant computed from the bulk properties of the phononic crystal, which ensures strong stability properties. This one-dimensional bulk-boundary correspondence has been proven in various works. Recent attempts have exploited the notion of surface impedance, relying on analytical calculations of the transfer matrix. In the case of second-order operators describing longitudinal waves, we prove the monotonic evolution of surface impedance with frequency, for all one-dimensional phononic crystals with mirror-symmetry (1). This result allows us to establish a stronger version of the bulk-boundary correspondence that guarantees not only the existence but also the uniqueness of a topologically protected interface state. This correspondence is extended to a larger class of one-dimensional models that include imperfect interfaces, array of resonators, or dispersive media. Numerical simulations are proposed to illustrate the theoretical findings. Current extension to fourth-order operators describing bending waves in Euler-Bernoulli beams is also addressed. (1) A. Coutant, B. Lombard, "Surface impedance and topologically protected interface modes in one-dimensional phononic crystals", *Proceedings Royal Society London A* 480 (2024), 20230533

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