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Distinct Exceptional Points in Hermitian Phononic Laminates

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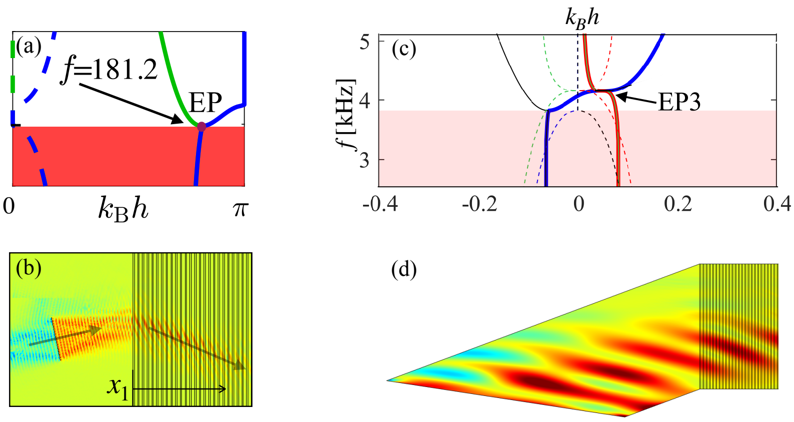
Open systems, described by non-Hermitian operators, can exhibit degeneracies where two or more of their eigenmodes coalesce. These degeneracies, termed *exceptional points* (EPs), present exotic wave phenomena and thus serve as a tool for metamaterial design. Most studies focus on temporal EPs, which form when two (or more) resonance frequencies coalesce. These works incorporate gain and loss that are often balanced to form PT symmetry for temporal stability.

Here, we present a framework that eliminates the need for material gain or loss by breaking spatial Hermitian symmetry using the features that are unique to elastodynamics. We design a unit cell with two isotropic Hermitian (conservative) materials to form a second-order EP, and show it give rise to negative refraction.



We extend our design and achieve the coalescence of three Bloch modes (EP3) using anisotropic material [Fig. (c)]. We show it gives rise to modes with zero axial group velocity and finite transmittance, known as 'axially frozen modes' [3]) [Fig. (d)]. These modes, previously discovered in 3D dielectric laminates [3], are now accessible in simpler, planar settings in elastodynamics, thanks to the distinct tensorial properties of elastodynamics.

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References

1. B. Lustig, G. Elbaz, A. Muhafra, and G. Shmuel, "Anomalous energy transport in laminates with exceptional points," *J Mech Phys Solids*, 133, 103719, 2019.

2. A. Fishman, G. Elbaz, T. V. Varma and G. Shmuel, "Third-order exceptional points and frozen modes in planar elastic laminates," *J Mech Phys Solids*, 186, 105590, 2024.

3. A. Figotin and I. Vitebskiy, "Oblique frozen modes in periodic layered media," *Phys Rev E*, 68, 036609, 2003.