What can topology teach us about the mechanics of metamaterials, and vice-versa?

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Abstract

In recent years, topology has profoundly deepened our understanding of collective phases of waves, from electrons to magnons. Here, I focus on mechanical metamaterials: can topology illuminate their behavior, and conversely, can mechanics reveal general properties of topological phases?

The topological characterization of mechanical systems dates back to Maxwell's seminal work, yet a recent reformulation enables a direct experimental measurement of topology in mechanical configurations (1). Remarkably, this approach requires no a priori theoretical model of the metamaterial, yet predicts the spatial location of low-energy deformations and self-stresses.

I will then discuss a distinct topological property emerging in the mechanics of non-orientable structures, exemplified by the Möbius strip (2). Its buckling modes vanish along the ribbon, effectively embedding an "edge state" within the bulk and challenging the conventional bulk–boundary correspondence that underlies most topological phases. Finally, I will show that this notion of non-orientable mechanics extends far beyond mechanical systems, shedding light on frustrated phases of matter across different physical contexts (3).

(1) M. Guzman et al., *PNAS* **121**, e2305287121 (2024).
(2) D. Bartolo and D. Carpentier, *Phys. Rev. X* **9**, 041058 (2019).
(3) X. Guo et al., *Nature* **618**, 506 (2023).

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