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Topological physics

It's time for some *K*-theory

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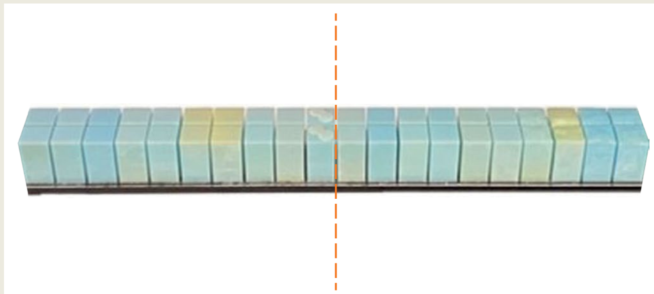
The study of crystalline systems in the 21st century has been heavily influenced by the role of topology. Some materials are topologically distinct from the empty space that surrounds them and feature surface states that are robust to disorder because of their topological origin.

However, the most common approaches to classify topological materials only work for materials like insulators that have a gap in their energy-level spectrum. Now, Wenting Cheng and colleagues have used ideas from the mathematical field of *K*-theory to verify experimentally that a gapless acoustic metamaterial is topologically non-trivial (*Nat. Commun.* **14**, 3071; 2023).

The energy levels of periodic systems form continuous bands that are separated from each other by so-called band gaps.



Because each band is discrete, topological invariants can be calculated for each of them. However, a system can still be topologically non-trivial without bands and a band gap, it just cannot be classified by these methods.

Cheng and colleagues constructed a topologically non-trivial gapless system from a one-dimensional array of acoustic resonators (a section is pictured). They started with an acoustic analogue of a topological system known as the Su–Schrieffer–Heeger model, which does have a gap. This was coupled to an additional array of resonators with energy levels inside the gap, so that the combined system was gapless.

The team's design included a defect in the centre of the Su–Schrieffer–Heeger chain (orange dashed line), which hosted a topologically protected state. This state persisted in the gapless system, reflecting its non-trivial topology.

To classify the topology of their device, Cheng and colleagues used an approach that compares the system to its atomic limit, in which all of the resonators are distant and uncoupled. An area of mathematics known as *K*-theory provides tools that can classify topologically distinct mathematical operators. The team applied these techniques to show that their model and its atomic limit were different, demonstrating that their system was non-trivial.

Cheng and colleagues' work is a demonstration of the continued benefits of applying pure mathematics to analyse physical systems. As these techniques become better understood and more sophisticated, so too will the field of topological materials.

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