

Sep 17th, 12:00 AM - Sep 19th, 12:00 AM

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Recommended Citation

Coulais, C. (2018). Non-reciprocity in Mechanical Metamaterials. In T. Siegmund & F. Barthelat (Eds.) *Proceedings of the IUTAM Symposium Architected Materials Mechanics, September 17-19, 2018*, Chicago, IL: Purdue University Libraries Scholarly Publishing Services, 2018. <https://docs.lib.purdue.edu/iutam/presentations/abstracts/17>

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Non-reciprocity in mechanical metamaterials

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KEYWORDS:

Non-reciprocity, Nonlinearity, Mechanical topological insulators, Active-feedback

We devise two classes of mechanical metamaterials that exhibit non-reciprocity, namely they transmit motion differently depending on the direction of the input forcing.

First, we introduce mechanical metamaterials that exhibit static nonlinear non-reciprocity [1]. We derive the fundamentals to obtain such static non-reciprocity and show that geometric asymmetry and nonlinearity are the two key ingredients. In particular: (i) we introduce a metamaterial which by harnessing elastic instabilities is able to perform up to 20dB one-way motion isolation (Fig. 1); (ii) we show theoretically and experimentally that metamaterials with non-trivial topological properties are a particularly fruitful paradigm to obtain non-reciprocity for low input forces.

Second, we introduce active-feedback mechanical metamaterials that exhibit linear non-reciprocity. We realize experimentally such a metamaterial that features a 35dB one-way motion isolation over a broad range (more than 2 decades) of frequencies.

Static nonlinear and broadband linear non-reciprocity might provide new strategies for shock absorption and energy harvesting applications.

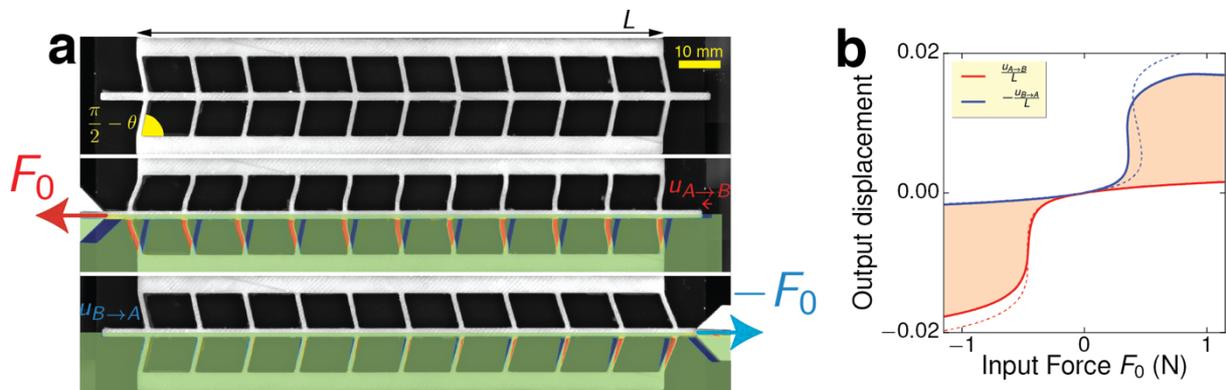


Fig. 1. Static Non-reciprocity in mechanical metamaterials. (a) Snapshots of the fishbone structure at rest (top), actuated from the left (middle) and from the right (bottom). The image difference has been overlaid on the bottom half of the pictures. (b) Output displacement vs. input force showing a strong non-reciprocal response (depicted by the shaded area). Adapted from [1].

References

- [1] C. Coulais, D. Sounas and A. Alù, "Static Non-reciprocity in mechanical metamaterials," *Nature*, vol. **542**, pp. 461-464 (2017)