CONSTITUTIVE MODELING OF CHIRAL MECHANICAL METASTRUCTURES

RIGHT RESULTS. AWAY.

OVERVIEW

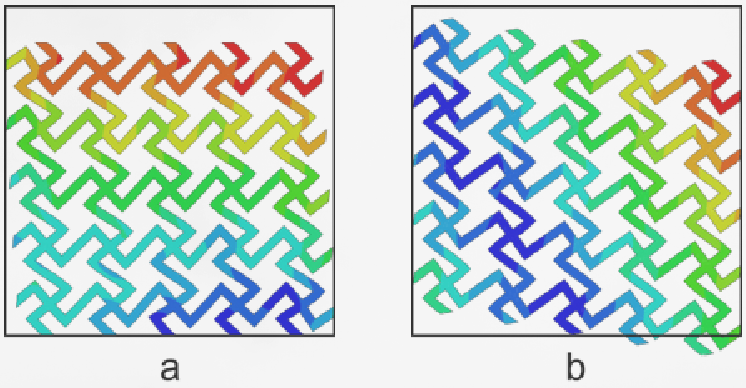
Mechanical metamaterials exhibit unique behaviors due to their engineered microstructures rather than their base material properties. Chiral metastructures, composed of asymmetric unit cells, are of particular interest due to their unconventional mechanical characteristics, including extension–twist coupling. This study utilizes the novel Mechanics of Structure Genome (MSG) approach to systematically model and analyze chiral metastructures.

This research enables efficient modeling of complex mechanical behaviors in metamaterials and provides design insights for lightweight, high-strength structures in aerospace applications. It also reduces experimental and computational costs by optimizing metastructure designs.

KEY BENEFITS

TECHNICAL APPROACH

The MSG framework is used to establish Euler–Bernoulli beam, Kirchhoff plate, and Cauchy continuum models. Various chiral unit cells are analyzed to determine size-dependent and size-independent mechanical properties. The study evaluates the extension–twist coupling, auxetic behavior, and shear coupling properties of these chiral metastructures.

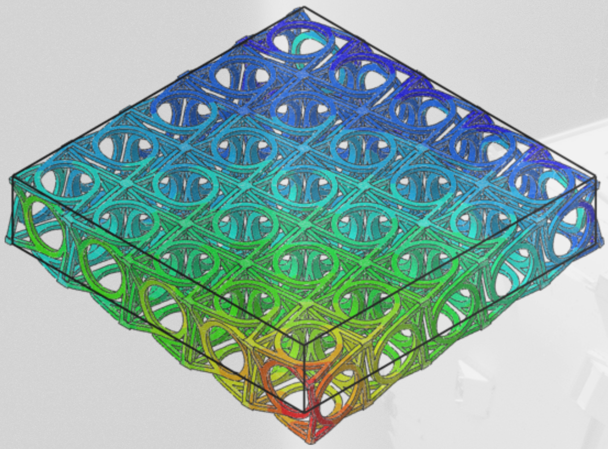


Deformed shape and undeformed edge of a missing rib metamaterial subject to (a) displacement- and (b) traction-controlled boundary conditions

RESULTS

The MSG framework effectively models beam-like, plate-like, and three-dimensional chiral metastructures. Chiral cubic unit cells exhibit size-dependent extension–twist coupling, confirming previous theoretical predictions. Contrary to prior assumptions, missing rib unit cells exhibit shear coupling rather than auxeticity. Various chiral metastructures demonstrate size-dependent bend–twist coupling behaviors.

APPLICATIONS



Deformed shape and undeformed edge of a plate-like chiral metastructure

MSG has applications in aerospace and defense for the design of energy-absorbing and lightweight structures. This model has the potential to reduce manufacturing, testing, and simulation efforts associated with metastructures. It is also useful in robotics and biomechanics for the development of flexible and high-strength robotic components. Additionally, it can be applied in thermal management through the utilization of negative thermal expansion metamaterials.

FUTURE DIRECTIONS

Future research includes investigating other 2D and 3D chiral unit cells for further insights into mechanical behaviors, exploring computational design optimizations for chiral metamaterials, and validating MSG-based models through experimental testing to refine predictive capabilities. Please contact us for additional information, free trial licenses, or to explore collaboration opportunities.