Elastic Wave Propagation in Periodic Solids (CIV ENV 419/ME 419)

Spring Quarter 2023

Periodic structures are fascinating systems that enable manipulation and control of elastic wave propagation in ways that are not achieved in natural materials, due to the interplay of lattice symmetry, wave scattering, and local elastic resonances. Research on periodic elastic structures has increased dramatically within the last decade and have led to innovative approaches to elastic wave filtering, energy harvesting, cloaking, seismic-wave shielding, super-resolution imaging, and heat conduction in atomic lattices. The objective of this course is to present the physics that underlies elastic wave propagation in periodic elastic solids, and to introduce contemporary experimental and numerical tools used to study the behavior of elastic waves in lattice structures. This course begins with an introduction to the elastodynamic wave equation, to describe the propagation of elastic waves in an elastic continuum, followed by representative models of spring-mass arrays, used to describe the dispersion, refraction, and beaming of elastic waves in periodic solids. Homework problem sets will be assigned to facilitate deep learning of important concepts covered in the course. The course will provide the background needed to pursue research in elastic wave propagation, elastic metamaterials, and phononic structures, and nanoscale thermal transport.

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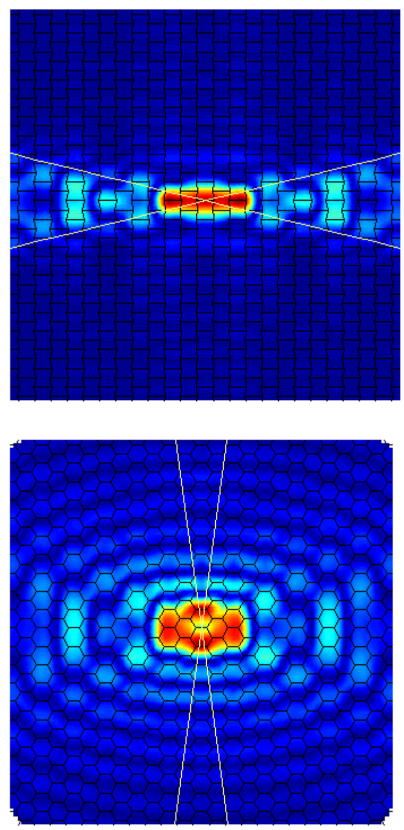
- **Class Hours**: Tu. Th. 3.30 – 4.50 PM
- **Classroom**: Tech. L251
- **Office Hours**: Monday 4-5 PM Online
- **Course website**: Canvas will be used to distribute homework assignments, lecture notes, and homework solutions



Elastic wave beaming in a 2D auxetic (top) and honeycomb lattice (bottom).

Grading

- Homework assignments: 40%
- Exam 1: 30%
- Exam 2: 30%

Supplemental References:

- Wave Propagation in Elastic Solids, J.D. Achenbach, (Elsevier, 1973)
- Acoustic Fields and Waves in Solids, B.A. Auld (Krieger, 1990)
- Introduction to Solid State Physics: Charles Kittel (Wiley, 2004)
- Acoustic Metamaterials and Phononic Crystals, Edited by P.A. Deymier (Springer,2013)

https://link.springer.com/book/10.1007/978-3-642-31232-8

Tentative Week by Week Schedule (Subject to change)

Week	Tuesday	Thursday
3/27	No lecture	Introduction Waves in a 1D continuum
4/3	Waves in a 1D continuum	Dispersion, distortion, group velocity
4/10	Tensors: review	Plane waves in a 3D continuum (Anisotropic solid)
4/17	Plane waves in a 3D continuum	Plane waves in a 3D continuum
4/24	Laboratory experiments	Discrete 1D monoatomic linear chain
5/1	Locally resonant 1D linear chain	Discrete 1D diatomic linear chain
5/8	Discrete 2D and 3D systems	Discrete 1D diatomic linear chain
5/15	2D discrete system: square lattice	2D square lattice: flexural waves
5/22	2D honeycomb lattice: flexural waves	Effective negative properties
5/29	Applications: negative metamaterials	Applications: negative metamaterials