Emergent phenomena in nonlinear metamaterials

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Introduction

Metamaterials are engineered structures in which the design of a meta-atom with specific dynamics gives rise to on-demand and unusual behavior of the artificial structure, making it possible to manipulate waves.

Research Objective

Reveal physical phenomena induced by material nonlinearities in locally resonant metamaterials and develop appropriated techniques for their analysis.

Methodology

Approximating techniques are used to describe the oscillatory motion of the nonlinear periodic system:

- **Harmonic Balance** method
- **Method of Multiple Scales**

Direct Numerical Simulations are performed in order to verify the approximating solutions.

Results

- **Dispersion Diagram**
- **Tunability**
- **½ Harmonic Band Gap**

Discussions

Results provide understanding of the effect of material nonlinearity in local resonant metamaterials.

- **Amplitude dependent** band gap position.
- **Shifting** band gap due to hardening/softening.
- **Co-existence** of acoustic and optical modes
- Possibility of generating ½ harmonic band gap in case of asymmetric stress-strain relation.

Outlook

- The features of nonlinear metamaterials make them promising for applications in: sensor technology, imaging, among others.
- Develop a numerical scheme involving both time and space to be incorporated into the classical Computational Homogenization.