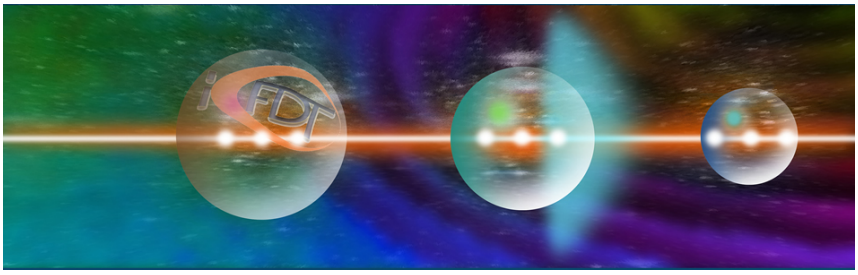

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Application of Phononic crystals and Acoustic Metamaterials to the detection and imaging of nonlinear defects

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Phononic crystals (PCs) and acoustic Acoustic metamaterials (AMMs) are artificially structured composite materials that enable manipulation of the dispersive properties of elastic waves, exploiting Bragg scattering or the presence of localized resonances. Generally, they are periodic distributions of cavities or inclusions (scatterers) embedded in a matrix. Among their unique vibrational characteristics, we recall effects such as frequency band gaps, negative refraction, wave filtering/focusing, acoustic cloaking, subwavelength sensing, etc. In particular, their ability to act as stop-band filters (opening bandgap in the frequency domain) and focus selected frequency bands make them potentially interesting for applications in nonlinear acoustics and structural health monitoring.
Nonlinear nondestructive techniques that exploit nonlinear signatures to detect and locate damage often encounter limitations linked to the weakness of nonlinear components of the signal, which can fall below the noise level, making it difficult to detect and estimate them. Here, we apply PCs and AMMs to Nonlinear Time Reversal (TR-NEWS) with specific designs that demonstrate the possibility of greatly enhancing the sensitivity of this nonlinear imaging technique. Moreover, we demonstrate that, combining the properties of higher order harmonic generation by nonlinear elastic materials and of suppression of selected frequencies by AMMs, it is possible to realize systems that can realize unidirectional nonreciprocal wave propagation, i.e. so-called “acoustic diodes”.

Summary

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