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Homogenized enriched continuum analysis of acoustic metamaterials with negative stiffness and double negative effects

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Abstract

This paper demonstrates the application of a recently developed enriched micro-inertial continuum based homogenization framework towards numerical dispersion and boundary value problem analyses of local resonance metamaterials exhibiting sub-wavelength negative stiffness and double negative effects (i.e. simultaneous negative effective mass density and stiffness). **This is a novel development since homogenized structural dynamic analyses that specifically incorporate negative stiffness effects have not yet been extensively explored.** The proposed methodology is successful in approximating the negative stiffness effect to a certain degree. Accordingly, an appropriate error estimation procedure based on dispersion analyses is proposed to identify the limits of the reliability of the homogenized model. The resulting methodology provides a highly efficient framework for the analysis of double negative metamaterial problems involving a non-trivial macroscopic loading, the influence of the applied boundary conditions, and a complex unit cell design. This is illustrated through a case study involving the refraction analysis of a double negative metamaterial prism.

Keywords: local resonance, double negativity, acoustic metamaterial, dispersion spectrum, multiscale analysis, homogenization

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