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Analysis and Design of Dispersive Materials and Structures

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Within periodically heterogeneous structures, wave scattering and dispersion take place across constituent material interfaces in such a way that an overall wave attenuation effect arises at certain frequency ranges known as stop bands. This phenomenon can be utilized in developing composite materials and structures with tailored frequency-dependent dynamic characteristics. The objectives of this work are twofold. First, a multiscale assumed strain variational formulation is developed for the prediction of frequency spectra of periodic materials. This approach facilitates the generation of reduced order models using mode projections. Second, computed frequency band structures are tailored to yield synthesized composite materials with desired dynamic characteristics. The designed materials are then used to form structures, at a larger length scale, for a variety of purposes. Applications include high-frequency vibration isolators and structural waveguides. For large systems, the multiscale projection methodology provides up to an order of magnitude reduction in size of computational problem compared to direct analysis. As for the multiscale design technique, this generates composite structures that are significantly more amenable to manufacturing compared to those generated via traditional topology optimization.

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