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Multiscale methods for engineering double negative metamaterials

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Abstract

The approach taken here solves the Maxwell equations inside metamaterial crystals directly and explicitly with no approximations made. The Bloch wave solution and dispersion relation is given by a power series in the ratio between wave number and period. Each term is iteratively defined by the solution of an auxiliary problem depending on the configuration and shapes of the scatterers. The leading order term in the power series for the dispersion relation is given by the complex effective index of refraction. The effective properties and their resonance frequencies depend explicitly on the shape of the scatterers. Double negative behavior is explicitly controlled by the location of resonance frequencies related to spectra intrinsic to the geometric configuration of the multi-phase inclusions. This provides for the rational shape design of inclusions for control of double negative behavior across prescribed frequency ranges.

Keywords: Metamaterial; Dispersion relation; Dissipative media