Unlocking Metamaterial Properties Through Multiscale Design

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Abstract

Extraordinary electromagnetic behaviour, such as negative magnetic permeability and negative refractive index, can be produced in metamaterial composites. A number of impressive specimens have been produced to date, though they typically rely on conductor inclusions with intricate topologies, or dielectric inclusions with very high permittivity. A challenge remains in designing metamaterials which have exotic properties and which can be manufactured efficiently.

We show that by designing the composite on two different length scales, we are able to bring about metamaterial behaviour using quite simple constituent materials and topologies. One scale is analyzed in the long wavelength limit, where a relatively low index material is mixed with a metal phase, producing material with a high effective index. This material is then used as the inclusion in the larger scale, where the high effective index can produce electric and magnetic Mie resonances, which we can use to produce the negative permeability and refractive index of the composite as a whole.

We design our composites in the 2D (fiber-type) space, which can be realized in large quantities using manufacturing techniques borrowed from fiber optics.

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