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A class of invisible graded index profiles and the control of electromagnetic waves

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Abstract – **We propose a general methodology to manipulate the amplitude of an electromagnetic wave in a pre-specified way, without introducing any scattering. This leads to a whole class of isotropic spatially varying permittivity and permeability profiles that are invisible to incident waves. The theory is illustrated through various numerical examples, including the non-magnetic case. The implementation of the required material properties using metamaterials is discussed, as well as extensions of the method for controlling the phase of electromagnetic fields.**

I. Introduction

Transformation optics [1] is a powerful analytic tool to design impedance-matched material, which gives rise to scattering-free wave solutions up to designer's will. However, this method inevitably requires the material parameter to be anisotropic, which complicates its manufacturing process. Therefore, an isotropic material to achieve the required wave solution may solve this issue. Here in this conference contribution, we try to reveal one method to serve the purpose to cater for designer's requirements for electromagnetic waves.

We will demonstrate a method to design isotropic material parameters in an optical inverse problem. We will start from vectorial Helmholtz equations [2] and show how one can find some exact wave solution in a corresponding inhomogeneous medium, where light wave and medium come in pairs. After that we exploit further the idea to seek the pair of wave solution and material parameters: spatial profiles of permittivity and permeability.

We demonstrate examples of how to control wave front – whether maintaining it or varying it at our will. For sake of simplicity, our design herein are all two-dimensional cases. However, this theory is generally applicable also in three-dimensional. Another instance we will show is a phase converter from a cylindrical wave to an planar wave as output. Our method is a general analytic tool to avoid unwanted scattering due to gradient-index profile of materials. In fact, it remains an open problem why wave encounters no scattering in such a medium.

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