Design of Mu-Near-Zero (MNZ) and Zero-Index Metamaterials Using Metallic or Plasmonic Non-Magnetic Dielectric Inclusions

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Zero-index materials are a class of metamaterials characterized by the fact that at some frequency band both the permittivity and permeability are near zero. While at the infrared and optical frequencies, some metals, low-loss dielectrics (e.g. silicon carbide) and semiconductors may have epsilon near zero (ENZ), materials with permeability near zero (or negative) are not readily available in nature. However, recent studies (R. W. Ziolkowski, Phys. Rev. E, 70, 046608 2004; N. Engheta, M. Silveirinha, A. Alù and A. Salandrino, ICEAA'05, Torino, Italy, Sept. 12-16, 2005, pp. 101-104) suggest that, if available, mu-near-zero (MNZ) and zero-index materials might have several important applications. These include controlling the far-field pattern of an antenna, transforming curved wavefronts into planar ones, designing delay lines, and enhancing the transmission efficiency of waveguides at junctions and bends. Thus, it is relevant to study if MNZ and zero-index materials can be fabricated artificially as metamaterials, i.e. as a host medium loaded with properly designed inclusions.

In this talk, we will show that it is possible to produce an MNZ and zero-index material by embedding non-magnetic dielectric particles in an ENZ dielectric host medium. The realization of MNZ and zero-index materials at microwaves will also be discussed. Previous related works (G. Shvets, Phys. Rev. B **67**, 035109 2003) have focused their attention in the design of double negative (DNG) materials. However, here we aim at MNZ and zero-index metamaterials.

In this work, we will prove that a metamaterial can be conceptually designed in such a way that both the effective permittivity and permeability are simultaneously zero, and explicit design formulas will be given. Different metamaterial realizations will be proposed. For a particular class of problems it will be analytically proved that matched zero-index metamaterials may help improving the transmission through a waveguide bend or channel, and that the scattering parameters may be completely independent of the specific arrangement of the inclusions and of the granularity of the crystal.