Resonance Phenomenon in Paired Epsilon-Negative and Mu-Negative Bilayers

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Metamaterials with negative real effective permittivity and permeability are being studied by several research groups worldwide. These materials can exhibit interesting features that may lead to unconventional phenomena in guidance, radiation, and scattering of electromagnetic waves. These media are termed with various terminologies such as "double-negative (DNG) media", "left-handed (LH) media", "backward-wave (BW) media", etc.

Most of the work reported in the recent literature has been focused on the wave interaction with the DNG media, either by themselves or in juxtaposition with conventional "double-positive" (DPS) media. However, materials in which only *one* of the two parameters of ε and μ has the negative real part, *not both,* may also exhibit unusual features when they are paired in a conjugate manner. Fredkin and Ron (*Applied Physics Letters*, vol. 81, pp. 1753-1755, September 2, 2002) have shown that such a combination can provide an effective group velocity that would be antiparallel with the effective phase velocity, and thus this combination may act as an equivalent LH medium. We have explored and analyzed thoroughly the wave interaction with a bilayer structure in which a slab of lossless material with negative real permittivity but positive real permeability (i.e., an epsilon-negative (ENG) medium) is paired with another slab made of a lossless material with positive real permittivity but negative real permeability (i.e., "mu-negative (MNG) medium), finding some interesting properties due to such juxtaposition of these "conjugate" layers. For instance, we have found that under certain sets of material parameters, the paired bilayer structure exhibits resonance phenomenon, and thus the wave can "tunnel" through completely, effectively making the pair transparent. We have analyzed the field distributions inside and outside such paired slabs, and obtained the reflection and transmission coefficients, while also focusing attention on the Poynting vector distributions. Furthermore, using equivalent transmission-line models with appropriate distributed series and shunt reactive elements, we can physically justify such effects and can describe the conditions on the slabs parameters for resonance, tunneling and transparency.

In this talk, some of the results of our analysis will be presented and discussed.