Wave Excitation and Propagation in a Dielectric Rod Array

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In recent years, a dielectric rod array is being investigated in two very different contexts: as a metamaterial structure and a forest scaled model. For metamaterial application, it was found that a periodic array of sub-wavelength spaced, high permittivity dielectric rods may be homogenized as an effective medium with negative effective permittivity ε and negative effective permeability μ. This finding leads to experimental observation of exotic electromagnetic phenomena such as the negative refractive index and the left-handed behavior (L. Peng et al., *Phys. Rev. Lett.*, 98, 157403, 2007). For forest scaled model application, a dielectric rod array consisting of water-filled straws was used to model a forest since the dielectric constant of water at microwave frequencies is close to that of typical pine trees at HF/VHF frequencies. The transmission data measured in the scaled model matched reasonably well the collected data in real forest environments (Y. Li and H. Ling, *IEEE Trans. AP.*, 58, 4025-4032, 2010).

Motivated by the above interesting applications, we investigate wave excitation and propagation in a dielectric rod array. First we review the effective medium representation of the rod array structure. Then we derive the radiated field expression for a Hertzian dipole embedded inside the array using an effective medium approach. Near electric fields are computed at different positions for both lossless and lossy dielectric rod arrays, and compared with full wave simulation results. The propagation characteristics (e.g., propagation constant, attenuation constant and modal field distribution) of guided slow modes inside the array are also extracted. Finally we examine far field radiation pattern of the electric dipole embedded in the dielectric rod array from both theory and simulation.