Tunneling In Photonic Crystals Consisting of Single-Negative Materials

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Much interesting has been attracted recently on metamaterials for their unusual properties of manipulating photons. There are mainly two kinds of metamaterials: double-negative materials (DNM) with ε<0 and μ<0; and single-negative materials (SNM) with ε<0 and μ>0 (ε-negative materials (ENM)), or ε>0 and μ<0 (μ-negative materials (MNM)). Contrasted to propagating modes in usual materials and DNM, SNM support only evanescent modes, leading to novel effects on photons transportation [1-4]. The theoretical and experimental studies of the present authors show that the tunneling, instead of the Bragg scattering, plays domain mechanism in 1D photonic crystals consisting of ENM and MNM. Our main results are: (1) There exits a "spatially-average-single-negative" (SASN) gap whose edges correspond to zero (volume) averaged permittivity ($\varepsilon_{eff} = 0$) and zero (volume) averaged permeability ($\mu_{eff} = 0$), and the SASN gap is invariant to the geometrical scaling and insensitive to the incident angle and disorder. (2) The SASN gap and tunneling in a heterostructure made of ENM and MNM are observed experimentally in a composite right/left-handed transmission line.

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