Dual Localized Defect Modes in One-Dimensional Photonic Lattices

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Photonic crystals, which are patterned with periodic dielectric structures, can generate a photonic bandgap (E. Yablonovich, Phys. Rev. Lett., vol. 58, 2059-2062, 1987). It has been the most interesting case and useful in practice when defects are introduced in photonic crystals in a controlled manner (E. Yablonovich, etc., Phys. Rev. Lett., vol. 67, 3380-3383, 1991), just as bandgap engineering in semiconductors. A line defect can form a wave guide, and a point defect can create a resonant cavity, so these defect modes are useful for the design of some optical devices.

It is not hard to make materials where both ε and μ vary periodically by the use of modern fabrication. When both ε and μ vary periodically, novel physical phenomena have been observed. For example, for certain cases, the bandgaps become wider (M. M. Sigalas, etc., Phys. Rev. B, vol. 56, 959-962, 1997).

In this abstract, by numerical simulations, we found that there exist two defect modes in exactly same location in the lowest bandgap in one-dimensional photonic crystals. By refining the mesh and increasing the cells of photonic crystals, numerical results show that these dual defect modes are stable.

We should point out that there also exist two defect (donor) modes in certain cases in three dimensional photonic crystals (E. Yablonovich, etc., Phys. Rev. Lett., vol. 67, 3380-3383, 1991), but the physical mechanism of the dual defect modes in a 1D photonic crystal is quite different.

Now we propose a physical mechanism for these dual defect modes. A ε periodic inhomogeneity with a defect generates one defect mode. A μ periodic inhomogeneity with a defect generates another defect mode. These two defect modes live on exactly same location, so at some cases, the strong coupling between them splits them into a lower and a higher mode. Since these dual defect modes have no analog in semiconductors, they may point to some important physical properties of photonic crystals.