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Zero-refractive-index property of plasma photonic crystal

Jianfei Li[1], Jingfeng Yao[1], Chengxun Yuan[1]
[1] School of Physics, Harbin Institute of Technology, Harbin 150000, People's Republic of China
e-mail (speaker): jianfei_li@hit.edu.cn

Photonic crystals, with their unique structural design, can realize the effective regulation of the relative permittivity and permeability of materials, and then manipulate the propagation of electromagnetic waves in photonic crystals. However, the band structures of all-dielectric photonic crystals are fixed once they are prepared, which greatly limits their practical applications.

The plasma photonic crystals constructed by gas discharge plasma and alumina arrays have the flexibility of being tunable and switchable. By tuning the plasma electron density, the bands positions can be changed. When the election density is increased to $1 \times 10^{12}\mathrm{cm}^{-3}$, a triple-degenerated Dirac-like cone can be obtained at the center of the Brillouin zone. As the electromagnetic waves are incident at the frequency of the Dirac-like point, the effective permittivity and permeability of the plasma photonic crystal are close to zero, which can realize the stealth effect on tiny targets. Figure 1 illustrates the transmission properties of electromagnetic waves in the plasma photonic crystal.

Experimentally, the transmission spectrum of electromagnetic waves transmitted in the plasma photonic crystal is measured, and a sharp transmission peak is found at the frequency of the Dirac-like point, and the phase there is unaffected by the discharge current, verifying the property of zero-refractive-index. The tunable band structures in plasma photonic crystals provide new ideas for the formation of accidentally degeneracy of Dirac-like cones.

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References

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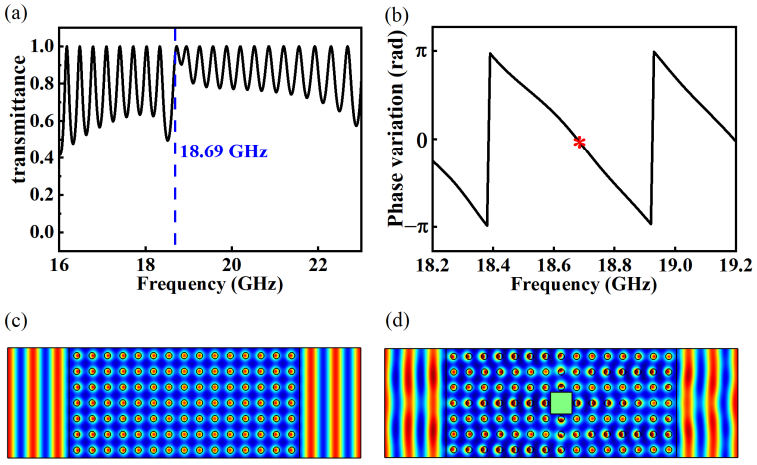

Figure 1. (a) The transmission spectrum versus to incident frequency. (b) The phase variation was detected from in-port and out-port. (c) The transmission of electromagnetic waves at Dirac like point. (d) The stealth effect for tiny targets.