Quasicrystal structure in metamaterials regime

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Introduction

Theory

Penrose tiling

Transmission

Phase transition

Conclusion

Periodic structures

Quasicrystal structures

Band diagrams are not existing in quasicrystal structures and we cannot see polaritonic feature in the metamaterial regime.

References

[1] Li, Kivshar, Rybin, ACS Photonics (2018)

Homogeneous mode is observed in the samples, which confirms the transition of the quasicrystal structure to the metamaterial mode. Analyze homogeneous mode, we constructed phase diagram.
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### Polaritonic feature

Typical band diagram for photonic crystal

Typical band diagram for metamaterials

*Polaritonic feature is a criterion of metamaterials*

**References**

[4] Li, Kivshar, Rybin, ACS Photonics (2018)

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### Photonic phase transition in periodic structures

Phase diagram “photonic crystal – metamaterial” for a square lattice of dielectric cylinders. TE polarization. The dielectric constant $\varepsilon$ of various materials is indicated by the horizontal lines.

The first way to make metamaterials is the decreasing lattice constant and the second one is the increasing dielectric permittivity.

**References**

Penrose tiling generate

Projection method to construct of one-dimensional quasicrystals of the Fibonacci type.

The projection of unit cell of a 5D hypercubic lattice into 3D space in the form of an icosahedron.

Penrose tiling

Structural factor

Real space

- Hexagonal lattice
- Square lattice
- Penrose lattice

Reciprocal space

For quasicrystals maxima in the reciprocal space become very dense including the area around the origin. As a result multipole Bragg bands appear in the low frequency range.

References

Transmission spectra for (a) photonic crystal, (b) quasicrystal; metamaterials: (c) periodic structure, (d) quasicrystal structure.

Dependence of minimum of transmission on number of rods. The transport regime in a quasicrystal is not the same as in the periodic structure; therefore, the close arrangement of diffraction maxima does not prohibit the existence of a metamaterial regime.
### Quasicrystal structure in metamaterials regime

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#### Homogeneous mode

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<th>$s$</th>
<th>$\varepsilon = 12$</th>
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Distribution of field for structures with Penrose lattice for different values of parameter $s$.

(a)-(c) photonic quasicrystals, (g)-(i) metamaterials.

#### Photonic phase transition

![Photonic phase diagram for structure with Penrose lattice.](image10.png)

**Photonic phase diagram** for structure with Penrose lattice.

- Quasicrystal metamaterials
- Photonic quasicrystals
1. The transport regime in a quasicrystal is not the same as in the periodic structures.
2. The appearance of a homogeneous mode confirms the transition of the quasicrystal structure to the metamaterial regime.
3. We constructed phase diagram “quasicrystal - metamaterial”.