Quasicrystal structure in metamaterials regime

Ekaterina E. Maslova[1], Mikhail V. Rybin[1,2]

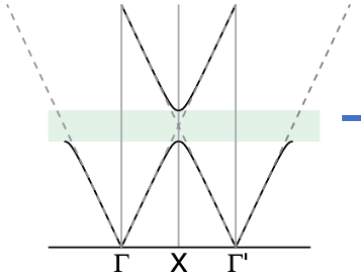
[1]Department of Physics and Engineering, ITMO University, St Petersburg 197101, Russia

[2]Ioffe Institute, St. Petersburg 194021, Russia

ekaterina.maslova@metalab.ifmo.ru

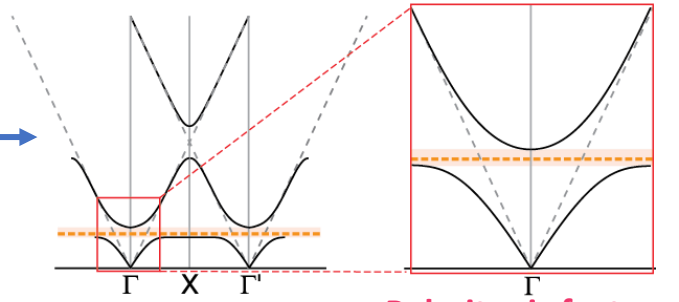
Periodic structures

Typical band diagram for photonic crystal



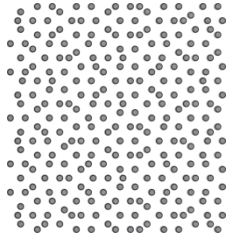
Photonic phase transition

Typical band diagram for metamaterials



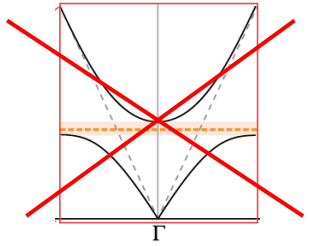
Polaritonic feature

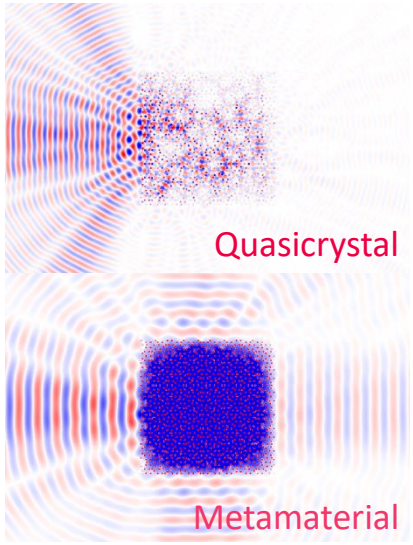
Quasicrystal structures



Penrose lattice

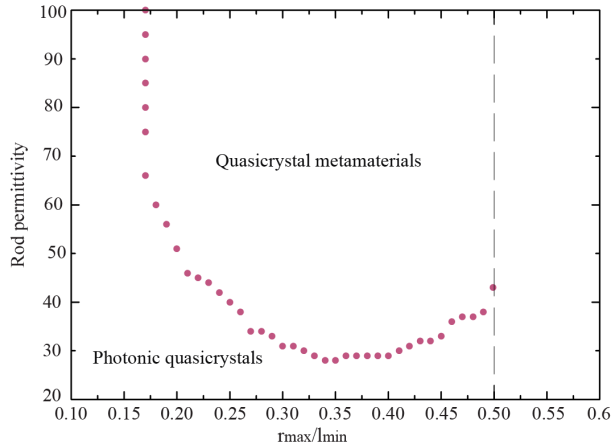
Band diagrams are not existing in quasicrystal structures and we cannot see polaritonic feature in the metamaterial regime.





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.



References

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

[2] X. Huang et al., Nat. mat. 10, 582–586 (2011).

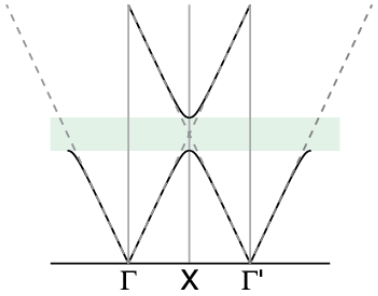
[3] J.-W. Dong et al., PRL 114, 163901 (2015).

Quasicrystal structure in metamaterials regime

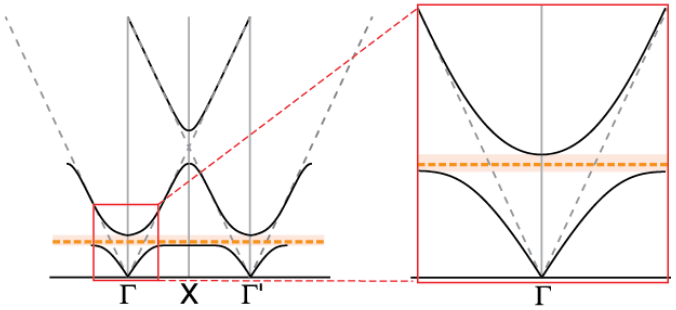
Ekaterina E. Maslova, Mikhail V. Rybin

Polaritonic feature

Typical band diagram for photonic crystal



Typical band diagram for metamaterials

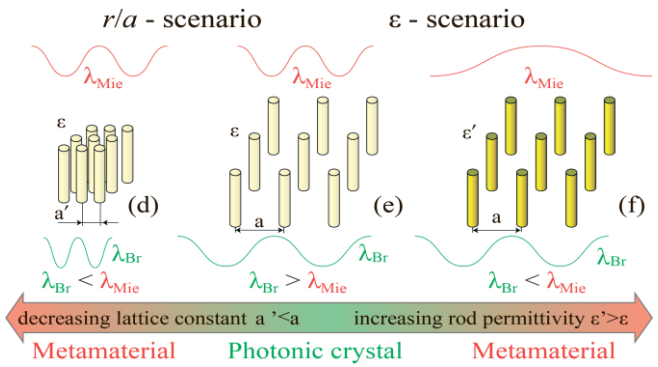


Polaritonic feature is a criterion of metamaterials

References

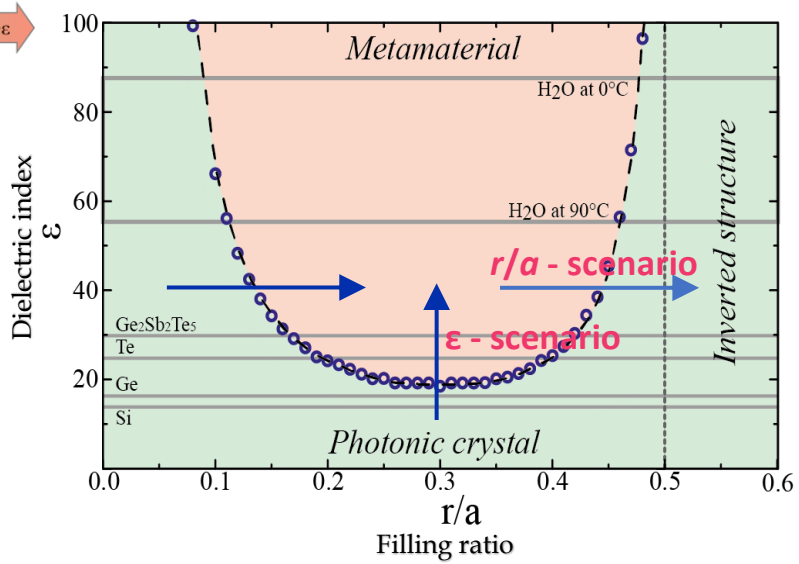
[4] Li, Kivshar, Rybin, ACS Photonics (2018)

Photonic phase transition in periodic structures



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

Phase diagram "photonic crystal – metamaterial" for a square lattice of dielectric cylinders. TE polarization. The dielectric constant ε of various materials is indicated by the horizontal lines.



References

[5] Rybin et al., Nat. Comm.(2015)

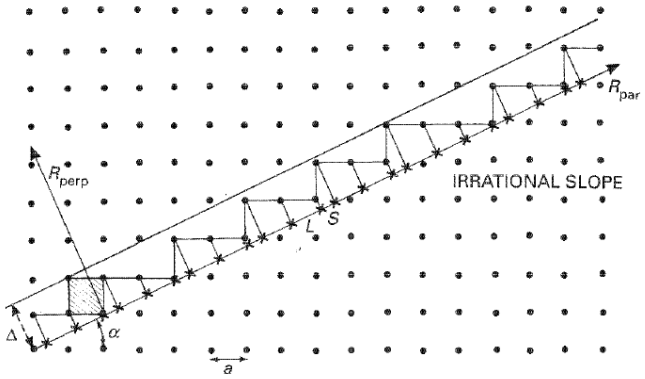
Quasicrystal structure in metamaterials regime

ITMO UNIVERSITY

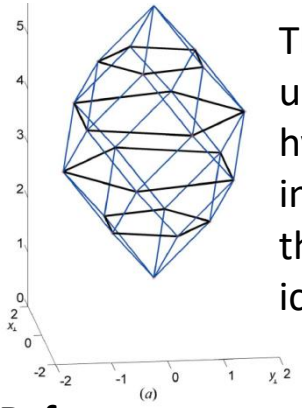
department of PHYSICS

Ekaterina E. Maslova, Mikhail V. Rybin

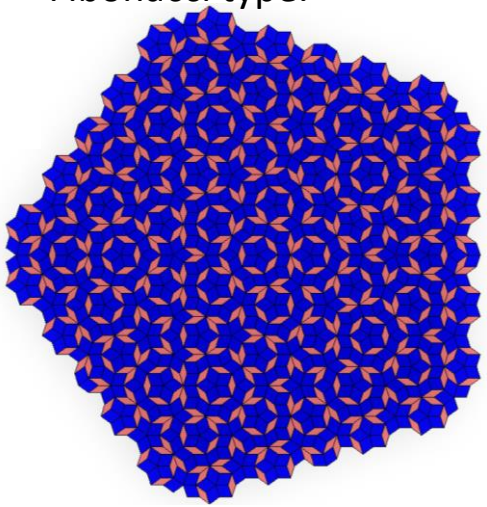
Penrose tilling generate



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.



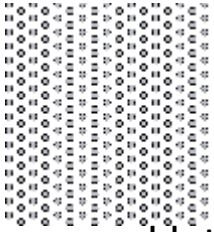
Penrose tilling

References

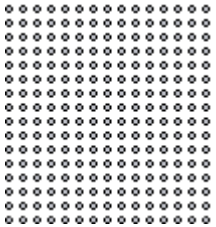
[6] M. Chodyn et al., Acta Cryst. (2015). A71, 161–168

Structural factor

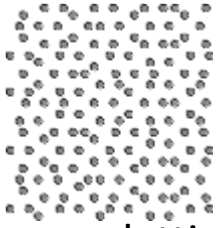
Real space



Hexagonal lattice

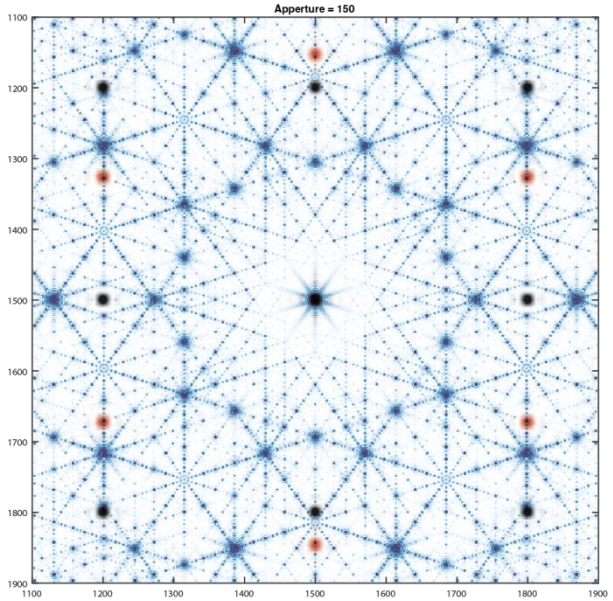


Square lattice



Penrose lattice

Reciprocal space

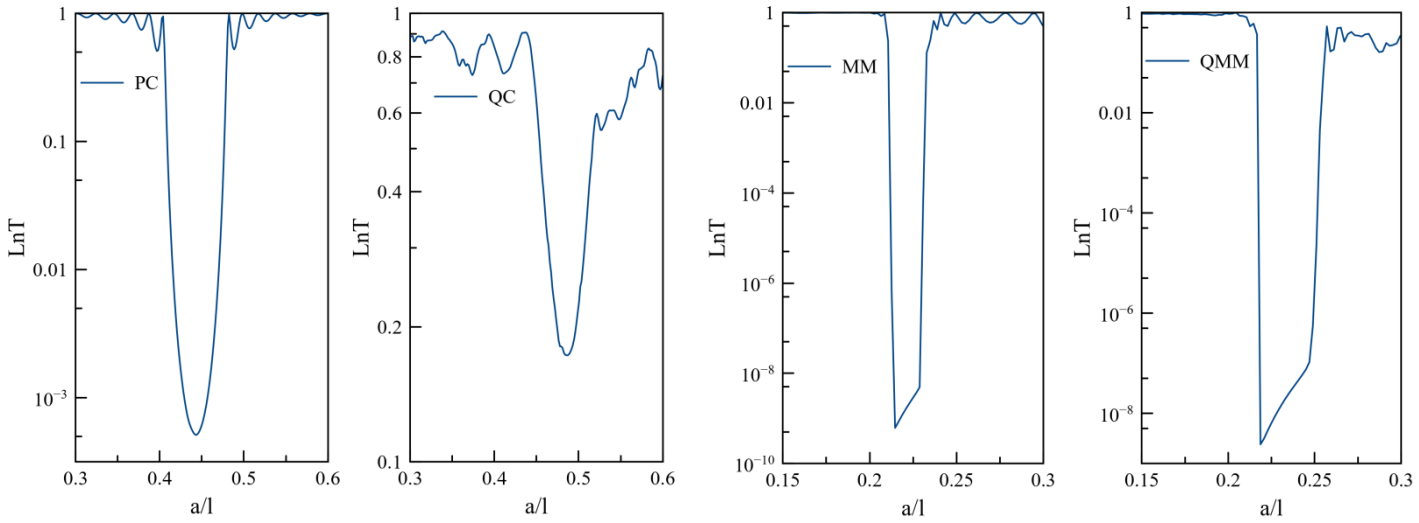


For quasicrystals maxima in the reciprocal space become very dense including the area around the origin. As a result multipole Bragg bands appear in the low frequency range.

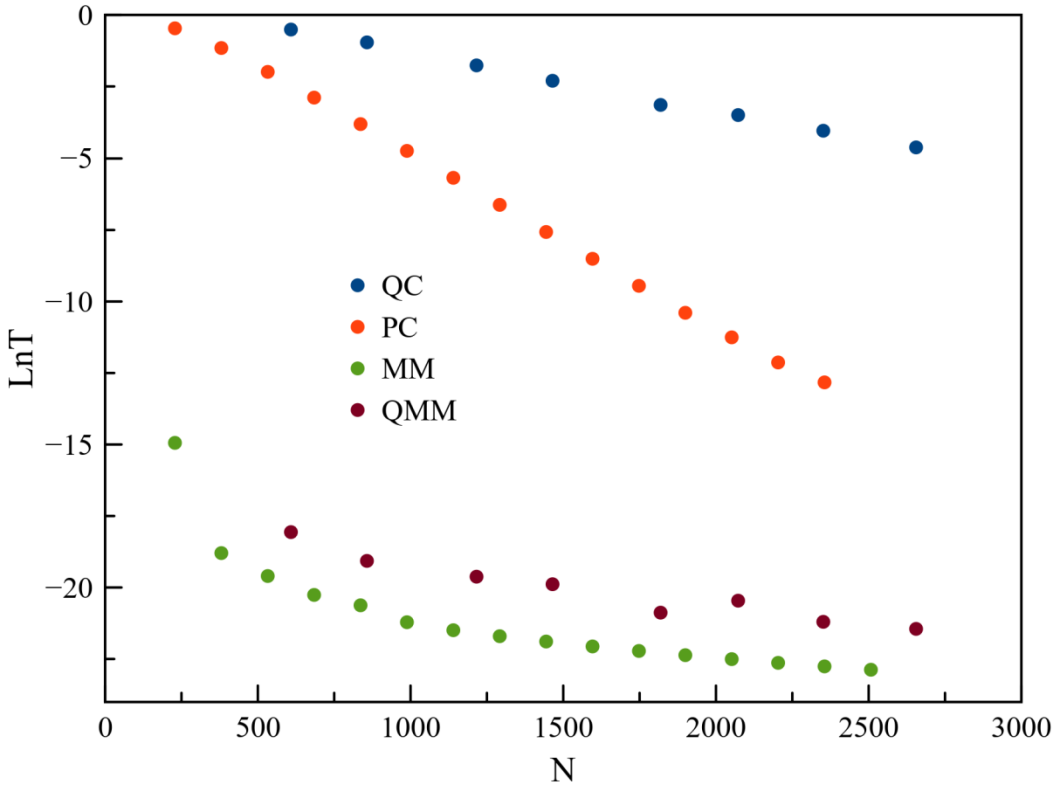
Quasicrystal structure in metamaterials regime

Ekaterina E. Maslova, Mikhail V. Rybin

Transmission spectrum



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

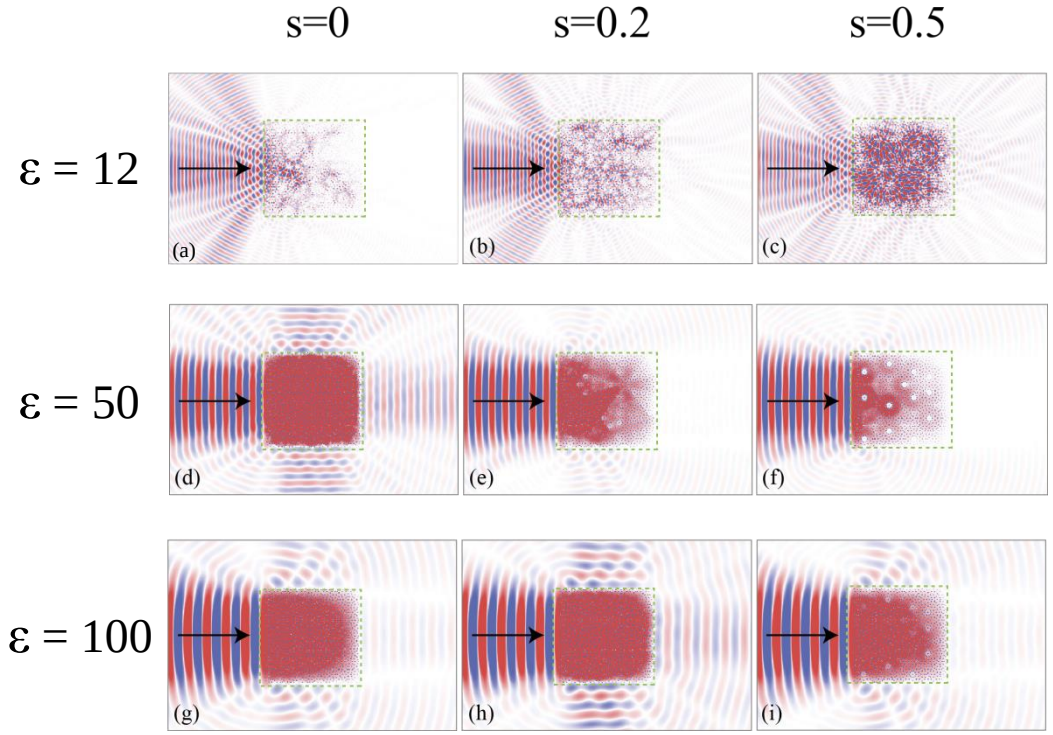


Dependence of minimum of transmission on number of rods. The transport regime in a quasicrystal is not the same as in the periodic structure; therefore, the close arrangement of diffraction maxima does not prohibit the existence of a metamaterial regime.

Quasicrystal structure in metamaterials regime

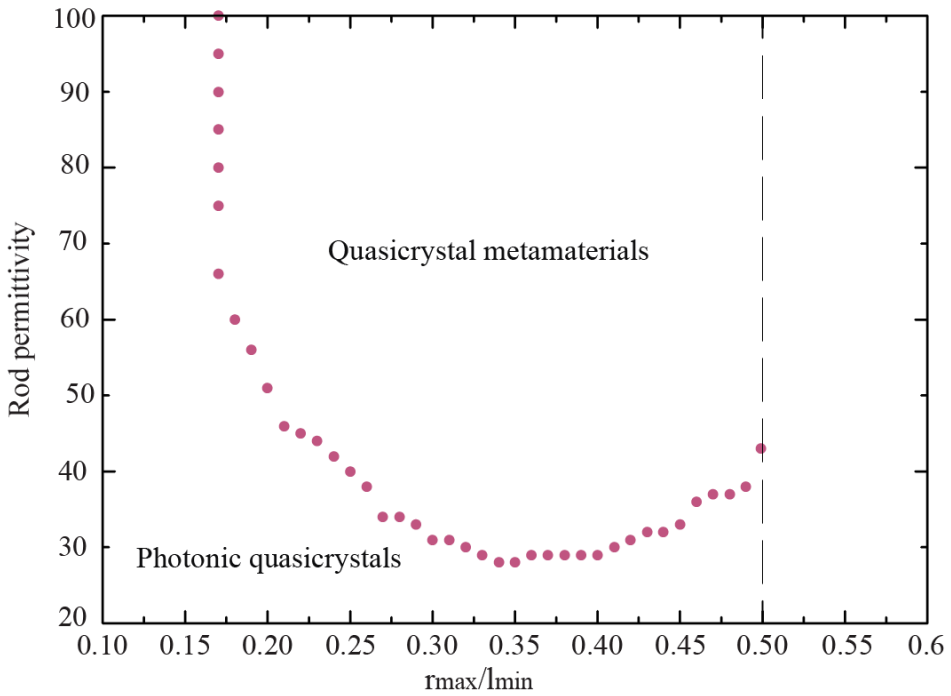
Ekaterina E. Maslova, Mikhail V. Rybin

Homogeneous mode



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.

Quasicrystal structure in metamaterials regime

Ekaterina E. Maslova[1], Mikhail V. Rybin[1,2]

[1]Department of Physics and Engineering, ITMO University, St Petersburg 197101, Russia

[2]Ioffe Institute, St. Petersburg 194021, Russia

ekaterina.maslova@metalab.ifmo.ru

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”.

ekaterina.maslova@metalab.ifmo.ru