Analytical Methods in Optics and Photonics

Лекторы:
Alexey Shcherbakov

Язык:
English
Трудоемкость:
6 ECTS
Форма контроля:
exam

Образовательная программа:
Advanced Quantum and Nanophotonic Systems
1 semester

Пререквизиты:
Mathematical Methods in Physics
Computational Electrodynamics I
Electrodynamics
Quantum mechanics
Numerical analysis and optimization methods in radiophysics

Лекции (ак.час)*	Практические занятия (ак.час)	Лабораторные занятия (ак.час)
16	16	
*1 академический час = 45 минутам		

The course focuses on a general analytical analysis of the time-harmonic electromagnetic fields based on the Green's functions and subsequent derivations of various numerical methods including the volume integral equation methods in the coordinate and in the reciprocal space. A special attention is payed to the Fourier space method and their application to analysis of physical phenomena in periodic structures. The approaches under consideration appear to be alternative to the widely used Finite Element and Finite Difference methods, though, appear to be superior to the named ones and can provide an additional physical insight into certain classes of problems in nanophotonics. Students will be given theoretical lectures, and will be offered several projects, which include both coding and analysis of physical phenomena.

Содержание курса

1 semester

Dyadic Green’s functions

Структура курса

1. Vector Hemlholtz equation
2. Electric and magnetic Green’s functions
3. Green’s function singularity
4. Eigenfunction decomposition of Green’s functions

1 semester

Plane wave decomposition

Структура курса

1. Plane waves
2. S- and T-matrices
3. Fabry-Perot resonator and planar waveguide

1 semester

1D and 2D photonic crystals and photonic crystal slabs

Структура курса

1. True Modal Method
2. Modes of 1D photonic crystals
3. Scattering matrix
4. Fourier Modal Method
5. Resonant phenomena in photonic crystals and photonic crystal slabs
6. Analysis of resonances via calculation of poles of S-matrices
7. Band diagrams of 1D/2D photonic crystals and photonic crystal slabs

1 semester

3D photonic crystals

Структура курса

1. Fourier method
2. Band diagrams of 3D photonic crystals

1 semester

Sylindrical and spherical wave decomposition

Структура курса

1. Green’s function decomposition
2. T-matrix

3. Scattering by multilayer cylinder and sphere
4. Resonances in spherical particles

1 semester

Multiple scattering

Структура курса

1. Dipole lattices
2. Lattice sums
3. KKR method
4. Multiple particle T-matrix

1 semester

Scattering by nonspherical particles

Структура курса

1. Discrete Dipole Approximation
2. Extended Boundary Condition Method
3. Invariant Imbedding Method

Рекомендуемые ресурсы

[1] W.C. Chew, Waves and Fields in Inhomogeneous Media, IEEE Press, N.Y., 1995

[2] А.А. Барыбин, Электродинамика волноведущих структур. Теория возбуждения и связи волн, Физматлит, М., 2007

[3] Y. Saad, Iterative methods for sparse linear systems. SIAM, 2003.

[4] E. Popov, ed., Gratings: Theory and Numeric Applications. Institute Fresnel, AMU, 2012.

[5] J. D. Joannopoulos, S. G. Johnson, J. N. Winn, and R. D. Meade, Photonic Crystals: Molding the Flow of Light (Second Edition), Princeton University Press, 2008

[6] A. Doicu, T. Wriedt, and Yu. Eremin, Light Scattering by Systems of Particles, Springer, 2006

Политика оценивания

Grading policy:

• 75% home assignments

• 25% final exam (theoretical questions)

9 Grading

• > 90 - excellent

• > 70 - good

• > 50 - satisfactory

• ≤ 50 - unsatisfactory