Level of education: **Master**
Field of study: **16.04.01 Technical Physics**

Advanced Quantum and Nanophotonic Systems

METHODS OF COMPUTER SIMULATION

Credits: 6 ECTS		
Semester		**Assessment**
2nd semester	6 ECTS	Exam

Course developers: **Roman Savelev**

The aim of the course is to provide a general overview as well as some specific details of solving different problems in the area of nano-optics and electrodynamics with commercial software packages “CST Microwave Studio” and “Comsol Multiphysics”. The program of the course focuses on such basic problems in nano-optics as

- calculation of eigenmodes of optical waveguides, optical resonators, including open resonators, and various periodic nanostructures;
- calculation of scattering properties of nanoparticles, resonators and metasurfaces under external far-field excitation;
- calculation of emission properties of dipole sources placed near optical nanoantennas, waveguides and cavities.

Part of the problems are solved in both CST and Comsol packages, which provides an opportunity to compare them in terms of simplicity of the construction of numerical models, speed and accuracy of the obtained results, and also qualitative difference between the programs. The physics of the considered problems is discussed in other courses, which, on one hand, helps to focus on the aspects of numerical simulation itself, and on the other hand, to improve the understanding of the physical essence of the considered problems during the process of modelling. In order to successfully finish the course, students need to solve by themselves several problems on the considered topics and to perform an accurate simulation of the resourceconsuming task based on one of the suggested papers.

Requirements

Course prerequisites:

Photonics, Computational Electrodynamics.

Course structure

1. Plane wave scattering at planar interfaces. Reflection and transmission of a plane wave from a single planar interface between two isotropic dielectric media or a parallel dielectric plate.
2. Optical waveguides. Calculation of eigenmodes and their excitation.
3. 1D and 2D photonic crystals: calculation of band structure; calculation of transmission and reflection from a PhC slab.
4. Scattering of light by nanoparticles (dielectric particles, plasmonic particles, microresonators).
5. Dielectric gratings and grating couplers, excitation of guided modes with gratings.
6. Coupling of dipoles to nanoantennas, waveguides and cavities.
7. Metasurfaces and multipole decomposition to control the propagating waves.
8. Multiphysics aspects: calculation of heat transfer and second harmonic generation. Integration with Matlab.

Assessment

Final mark (and mid-term attestation) is based solely on the performance during the semester. Each covered topic gives 1 point provided it was done not later than 1 week after scheduled time, and 0.5 point if it was done after 1 week.

Criterion for the exam grade:

- Excellent if you solve coursework problem and get 12 points (6 for CST classes, 6 for Comsol);
- Good for ≥12 points or ≥8 points + coursework;
- Satisfactory for ≥8 points.

Faculty: **Faculty of Physics**

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Tags: **Numerical calculation, CST Microwave studio, COMSOL Multiphysics**