ITMO University

Photonics

Course Workload		Assessment form (examination/ graded test/ ungraded test)
ECTS	**Hours**	
6	**216**	**Exam**

The course aims at giving the students the basics of modern photonics and consider the basic practical tasks in this area. The course begins with a study of the theory of metallic and dielectric waveguides and optical resonators. The physical effects underlying the control of electromagnetic radiation are examined in detail. We will study methods that allow us to analyze the capture of light in resonators and its propagation in the simplest waveguide systems. Moreover, the course presents the basics of the theory of photonic crystals, coupled modes approach and scattering theory including Mie-task.

Course structure:

1. Theory of waveguides

1.1. Waveguide as a quantum well for photon. Geometrical theory of waveguides. Parallel plate hollow waveguide with metal claddings
1.2. Parallel plate dielectric waveguide. Frequency cut-off. Asymmetric waveguides
1.3. Cylindrical waveguides and optical fibers
1.4. Goos-Hanchen shift. Losses in waveguides. Propagation length

2. Theory of optical resonators

2.1. S-matrix and its properties. Reciprocity
2.2. Fabry-Perot resonator. Eigenmodes. Quasi-normal modes. Quality factor and finesse. Resonant transmission. Impedance matching and absorption
2.3. Whispering gallery mode resonators

3. Photonic Crystals

3.1. Bragg reflector. T-matrix

3.2. Band structure of 1D, 2D and 3D photonic crystals. Photonic band gap and quarter-wave condition
3.3. Width of photonic gap. Weak contrast approximation. Coupled mode theory
3.4. Effective medium approximation for multilayer structures. Hyperbolic metamaterials
3.5. Photonic crystal cavity

4. Coupled mode theory

4.1. Reciprocity theorem. Orthogonality of waveguide modes
4.2. Coupling between two parallel waveguides. Power exchange. Eigenmodes
Topic

5. Scattering theory

5.1. Lippmann-Schwinger equation. Dyadic Green’s function. Optical cross sections. Scattering in the dipole approximation
5.2. Vector spherical harmonics. Mie theory. Multipole expansion. Kerker effect
5.3. Optical theorem