COURSE DESCRIPTION CARD - SYLLABUS

Course name
Quantum optics [S2FT2>OK]

Course

Field of study
Technical Physics

Year/Semester
1/2

Area of study (specialization)
–

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

1,00

Coordinators

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Lecturers

Prerequisites

Knowledge and skills in quantum physics and the foundations of quantum engineering, atomic, molecular and solid state physics, optical devices and laser optics, photonics and laser spectroscopy. Competencies in higher mathematics consistent with the learning outcomes for the first-cycle studies in technical physics and the ability to think algorithmically. The ability to self-educate and obtain information from scientific literature.

Course objective

1. Providing students with structured knowledge of quantum states of the electromagnetic field and related quantum processes in the context of potential applications in quantum information processing, quantum communication, quantum metrology. 2. Developing students' skills in algorithmic analysis of quantum optical processes and modular planning of experiments in the area of quantum optics.

Course-related learning outcomes

Knowledge:
Student:
1. Identifies and characterizes quantum states of light based on their mathematical description.

2. Knows the methods of optical implementation of processes and functions of optical modules for the implementation of selected quantum logical operations in implementation on quantum states of light or induced by them in matter.
3. Indicates prospective directions of development and applications of optical quantum technologies.

Skills:
Student:
1. Is able to select a method for detecting specific quantum states of light and propose its implementation using optical functional modules
2. Is able to propose an algorithm for realizing quantum optical processes adequate for realizing specific quantum logical operations or interferometric measurements

Social competences:
The student understands the necessity of iterdisciplinary cooperation in the implementation of projects related to quantum information processing implemented on quantum states of light.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

In terms of the methods used to verify the achieved learning outcomes, the following grade thresholds are used:
50.1-60% - 3,0;
60.1-70% - 3.5;
70.1-80% - 4.0
80.1-90% - 4.5
from 90.1% - 5.0.
The grade is based on individual written work and/or oral response.

Programme content

I Quantization of the electromagnetic field and characterization of quantum states of light
II Quantum interferometry and optical quantum logic
III Interaction of light with matter and light-induced atomic quantum logic

Course topics

1. Quantization of the electromagnetic field (light).
2. Mathematical description and detection of quantum states of the electromagnetic field (light).
3. Beam splitter and quantum optical interferometry.
4. Quantum operations performed on quantum states of light - optical quantum logic.
5. Selected aspects of the interaction of the atom with the quantum electromagnetic field.
6. Atomic quantum logic induced by light.
7. Quantum light-matter interfaces as elements of quantum networks.

Teaching methods

Lecture: multimedia presentation

Bibliography

Basic:
1. Sintayehu Tesfa, Quantum Optical Processes. From Basics to Applications, Springer 2020
2. Miguel Orszag, Quantum Optics, Including Noise Reduction, Trapped Ions, Quantum Trajectories, and Decoherence, Springer 2024

Additional:
1. Articles from scientific journals relevant to the given lecture topic
2. Ray LaPierre, Getting Started in Quantum Optics, Springer 2022
3. Serge Haroche, Jean-Michel Raimond, Exploring the Quantum: Atoms, Cavities, and Photons, Oxford University Press, 2021

Breakdown of average student's workload

	Hours	ECTS
Total workload	25	1,00
Classes requiring direct contact with the teacher	15	0,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	10	0,50