UNIWERSYTET IM. ADAMA MICKIEWICZA W POZNANIU

Quantum Information and Optics

Educational subject description sheet

Basic information

Study programme Fizyka **Speciality** INFORMACJA KWANTOWA I SPINTRONIKA **Organizational unit** Faculty of Physics **Study level** Second-cycle programme **Study form** Full-time **Education profile** General academic	**Didactic cycle** 2023/24 **Subject code** 04FIZIKSS.21S.04342.23 **Lecture languages** English **Course type** Obligatory **Block** specialty subjects

Subject coordinator	Adam Miranowicz
Lecturer	Adam Miranowicz

Period	**Activities and hours**	**Number of ECTS points**
Semester 1	• Lecture: 30, Exam • Classes: 30, Graded credit • Laboratories: 30, Graded credit	7

Goals

Code	Goal
C1	Providing students with basic concepts and methods of theoretical and experimental quantum information and quantum optics within the scope defined by the program content.
C2	Developing in students the ability to solve simple analytical and numerical problems based on the acquired knowledge, as well as the ability to plan and implement various quantum algorithms in a programming language chosen by students.
C3	Forming in students the skills of independent self-education and teamwork skills.

Subject learning outcomes

Code	Outcomes in terms of	Learning outcomes	Examination methods
Knowledge – Student:			
W1	acquires basic knowledge of quantum computer science focused on its optical implementations, within the scope defined by the program content.	FIZ_K2_W01, FIZ_K2_W02, FIZ_K2_W03, FIZ_K2_W04	"Open book" exam, Written colloquium, Project, Report
Skills – Student:			
U1	develops the ability to solve simple quantum-information problems based on the acquired knowledge, as well as the ability to performing numerical simulations of quantum algorithms.	FIZ_K2_U01, FIZ_K2_U02, FIZ_K2_U03, FIZ_K2_U04, FIZ_K2_U05, FIZ_K2_U06, FIZ_K2_U07	Project, Report
Social competences – Student:			
K1	develops the skills of self-learning and teamwork.	FIZ_K2_K04	Project
K2	is ready to critically evaluate his/her knowledge and content received, and to consult the knowledge and problems with experts, while trying to maintain independent and critical thinking, using the motto of Richard Feynman: "Science is the belief in the ignorance of experts. When someone says 'science teaches such and such', he is using the word incorrectly. Science doesn't teach it; experience teaches it."	FIZ_K2_K01, FIZ_K2_K02	Project

Study content

No.	Course content	Subject learning outcomes	Activities
1.	Week 1 Introduction to quantum optics and quantum information Week 2 Quantum interference: paradoxes and applications Week 3 Squeezed states and detection of gravitational waves Week 4 Schrödinger cat paradox and its applications Week 5 Quasiprobabilities and tests of nonclassicality Week 6 Quantum entanglement and quantum nonlocality Week 7 Quantum teleportation, entanglement swapping, and dense coding Week 8 Quantum tomography Week 9 Two models of quantum computing via quantum gates and quantum annealing Week 10 Superconducting quantum computers Week 11 Linear-optical quantum computers Week 12 Quantum error correction codes Week 13 Quantum algorithms I Week 14 Quantum algorithms II Week 15 Quantum supremacy and the future of quantum technologies	W1, U1, K1, K2	Lecture, Classes, Laboratories

Additional information

Activities	Teaching and learning methods and activities
Lecture	Lecture with a multimedia presentation of selected issues, Conversation lecture, Discussion, Problem-based learning

Activities	Teaching and learning methods and activities
Classes	Conversation lecture, Problem-based lecture, Problem-based learning, Solving tasks (e.g. computational, artistic, practical)
Laboratories	Solving tasks (e.g. computational, artistic, practical)

Activities	Credit conditions
Lecture	80% either an oral exam or solving and describing a selected research problem in the form of a report, which should include the student results of numerical simulations and/or analytical calculations; 20% activity during lectures and tutorials.
Classes	60% performing analytical and/or numerical calculations of selected standard quantum-information problems 40% activity during classes
Laboratories	60% performing analytical and/or numerical calculations of selected standard quantum-information problems 40% activity during classes

Literature

Obligatory

1. selected chapters in: C.C. Gerry, P.L. Knight, Introductory Quantum Optics (Cambridge University Press, 2004). Polish edition: Wstęp do optyki kwantowej (PWN, 2007)
2. selected chapters in: M.A. Nielsen, I.L. Chuang, Quantum Computation and Quantum Information (Cambridge University Press, 2000)

Optional

1. S. Haroche, J.M. Raimond, Exploring the Quantum: Atoms, Cavities, and Photons (Oxford University Press, 2000).
2. Thomas Wong, Introduction to Classical and Quantum Computing, http://www.thomaswong.net/

Calculation of ECTS points

Activities	Activity hours*
Lecture	30
Classes	30
Laboratories	30
Preparation for classes	15
Reading the indicated literature	10
Preparation of a project	20
Preparation for the exam	30
Preparation of a multimedia presentation	5
Other	10

Student workload	**Hours** 180
Number of ECTS points	**ECTS** 7

* academic hour = 45 minutes

Efekty uczenia się dla kierunku

Kod	Treść
FIZ_K2_K01	The graduate is ready to critically evaluate own knowledge and received content
FIZ_K2_K02	The graduate is ready to recognize the importance of knowledge in solving cognitive and practical problems and seeking expert opinion (also from other scientific disciplines) to overcome difficulties during independent problem solving
FIZ_K2_K04	The graduate is ready to think and act in an entrepreneurial manner
FIZ_K2_U01	The graduate can use their knowledge to formulate and solve complex and unusual problems in the field of physical sciences; select and apply appropriate methods and tools necessary to solve a given problem (including advanced IT techniques), as well as adapt existing methods and tools or develop completely new ones
FIZ_K2_U02	The graduate can find the necessary information in the professional literature, databases and other sources, in particular in scientific journals basic to physics, and perform critical analysis, synthesis and creative interpretation of the collected information
FIZ_K2_U03	The graduate can formulate and test hypotheses related to simple research problems in physics (plan and perform observations, experiments, theoretical calculations or computer simulations and critically evaluate and discuss the results obtained)
FIZ_K2_U04	The graduate can prepare, for various audiences, oral presentations and written studies presenting specialized topics in the field of physical sciences in a communicative way, as well as debate on such topics
FIZ_K2_U05	The graduate can use English in accordance with the requirements set out for level B2+ of the Common European Framework of Reference for Languages, as well as specialist English terminology in the field of physical sciences
FIZ_K2_U06	The graduate can interact with others as part of teamwork and take a leading role in such work; manage team work
FIZ_K2_U07	The graduate can independently determine the directions of further learning and implement a self-education program, learn throughout lifetime using the available international literature and be able to guide others in this regard
FIZ_K2_W01	The graduate knows and understands in-depth selected facts, phenomena, concepts and theories specific to physics and complex relationships between them (constituting advanced general knowledge in the field of physical sciences and representing both key and other selected issues in the field of advanced detailed knowledge in this discipline)
FIZ_K2_W02	The graduate knows and understands in-depth selected research methods and tools as well as mathematical models used in physics
FIZ_K2_W03	The graduate knows and understands in-depth selected computational methods and information technology tools and techniques used to solve complex problems in physics
FIZ_K2_W04	The graduate knows and understands main development trends in the discipline of physical sciences