KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

Projekt współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego

UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ SPOŁECZNY

Course title	ECTS code
Mathematical methods of quantum information	13.2.0415

Name of unit administrating study

Faculty of Mathematics, Physics and Informatics

Studies

faculty	field of study		
Faculty of Mathematics, Physics and Informatics	Quantum Information Technology	type	all
		form	all
		specialty	all
		specialization	all

Teaching staff

dr hab. Marcin Marciniak; prof. UG, dr hab. Adam Rutkowski; dr Stefano Cusumano; mgr Ekta Panwar

Forms of classes, the realization and number of hours

Forms of classes

Auditorium classes, Lecture

The realization of activities

classroom instruction, online classes

Number of hours

Auditorium classes: 30 hours, Lecture: 30 hours

ECTS credits

5

The academic cycle

2022/2023 winter semester

Type of course

obligatory

Language of instruction

english

Teaching methods

- critical incident (case) analysis
- discussion
- multimedia-based lecture
- problem solving
- problem-focused lecture

Form and method of assessment and basic criteria for eveluation or examination requirements

Final evaluation

- Graded credit
- Examination

Assessment methods

- (mid-term / end-term) test
- written exam (test)
- oral exam

The basic criteria for evaluation

Exams (Lecture and Exercises): correct answer to at least 60% of the questions. Evaluation criteria and exams' tentative schedule will be communicated to the students during the first classes.

Method of verifying required learning outcomes

Required courses and introductory requirements

A. Formal requirements

no formal requirements

B. Prerequisites

Basic knowledge of mathematics at high school level is required.

Aims of education

The aim of this lecture is to provide students with mathematical knowledge to understand basic concepts of quantum information theory as well as formulate and solve problems within this theory

Course contents

The content of the course includes the presentation of the following concepts (lecture and exercises will be devoted to the same issues):

Basic concepts of linear algebra: linear space, linear operator, matrix calculus
Basic concepts of functional analysis: Banach and Hilbert spaces, bounded and unbounded operators, different types of norms, self-similar operators, spectral theorem, functional calculus, positive definite operators
POVM and quantum measurement
Tensor products of Banach spaces and Hilbert spaces, operators on tensor products, Schmidt decomposition, Schmidt degree and Schmidt number, mathematical definition of entanglement, PPT states
Fock space, CCR and CAR relations
Positive and fully positive maps on matrix algebras: k-positivity, decomposability, entanglement witnesses
Quantum channels, capacity of quantum channels, additivity problem
Tensor products of positive maps and entanglement distillation, boundf entanglement

Bibliography of literature

O. Bratteli, D Robinson, „Operator algebras and statistical mechjanics" vol. I
E. Stormer, "Positive maps on operator algebras"
M. Hayashi, Quantum information theory. Mathematical foundation"
B.C. Hall "Quantum theory for mathematicians"
Material provided by the lecturer.

The learning outcomes (for the field of study and specialization)

K_W02
Student has in-depth knowledge of advanced mathematics, mathematical and computer methods necessary to solve physical problems of medium complexity and advanced in the area of quantum information and its technological aspects

K_W04
Student knows the advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics

K_U02
Student can apply mathematical knowledge to formulating, analyzing and solving problems related to information theory

Knowledge

W01:
Student knows and understands the basic mathematical concepts used in foundations of quantum information. (K_W02)
W02
Student knows the mathematical formulation of quantum mechanics and quantum information concepts (KW_04)

Skills

U01
Student is able to formulate and solve mathematical problems within the framework of quantum information theory (K_U02)
U02
Student is able to translate physical and quantum information problems into mathematical formalism and vice versa (K_U02)

Social competence

K01
to be completed

Contact

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