KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

Projekt współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego

UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ SPOŁECZNY

| Course title | ECTS code |
|---|---|
| Quantum Dynamics and Open Systems | 13.2.0424 |

**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**

prof. dr hab. Robert Alicki; prof. UG, Łukasz Rudnicki

**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**

Lecture: 30 hours, Auditorium classes: 30 hours

**ECTS credits**

5
lecture 3 ECTS
exercises 2 ECTS

**The academic cycle**

2022/2023 winter semester

**Type of course**

obligatory

**Language of instruction**

english

**Teaching methods**

- multimedia-based lecture
- problem-focused lecture
- project-based method (research, implementation, practical project)

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

**Final evaluation**

- Graded credit
- Examination

**Assessment methods**

- Research-like group project performed within the classes. Optional oral exam for students aiming at highest rank
- (mid-term / end-term) test
- written exam (test)

**The basic criteria for evaluation**

Quality of the final project report, engagement in the process of its preparation.

**Method of verifying required learning outcomes**

**Required courses and introductory requirements**

**A. Formal requirements**

none

**B. Prerequisites**

Knowledge of basic quantum mechanics and mathematics (algebra & analysis

**Aims of education**

To familiarize the students with the field of open system dynamics

**Course contents**

Mathematical formalism of quantum mechanics. Hilbert spaces, observables, pure and mixed states.
Dynamics of isolated quantum systems. Schroedinger, Heisenberg and interaction pictures.
Elements of scattering theory. Wave operators , T-matrix and S-matrix.

Formalism of second quantization.
Quantum open systems and reduced dynamics.
Completely positive dynamical maps. Kraus representation and unitary dilation.
GKLS-generators for quantum Markovian dynamics.
Von Neumann entropy and related functionals. H-theorems for quantum open systems.
Exactly solvable models of quantum open systems. Friedrichs model and spin-boson model with pure decoherence.
Quantum Markovian Master Equations in weak coupling and low density limits.
Examples of QMME for 2-level system and harmonic oscillator.
Stationary states and detailed balance condition.
Models of quantum heat engines.
Thermodynamics in quantum domain. Selected topics.

## Bibliography of literature

H.-P, Breuer and F. Petruccione, Theory of Open Quantum Systems, OUP, Oxford 2002
R. Alicki and K. Lendi, Quantum Dynamical Semigroups and Applications, LNP 717, Springer 2007
A. Rivas and S.F. Huelga, Open Quantum Systems, Springer 2012

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

K_W01
Student has extensive knowledge of general physics and advanced knowledge in the area of quantum information theory; knows the history of the development of quantum information theory and its importance for the progress of science, world cognition and social development

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_W06
Student has knowledge of the current trends in the development of physics, in particular within the quantum information theory

K_U01
Student is able to apply the scientific method and physical knowledge in solving problems formulated in the theory of quantum information, carrying out experiments and making conclusions

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

K_U09
Student can work independently and in a team

K_K03
The student is able to work individually and in a team; is aware of the responsibility for jointly performed tasks

## Knowledge

W01: Student knows basic concepts of the theory of quantum dynamics and open systems (K_W01, K_W06)
W02: Student knows mathematical notions and methods used within the framework of the theory of quantum dynamics (K_W02, K_W04)
W03: Student knows the basics of the theory Markovian dynamics and recent developments (K_W01, K_W06)
W04: Student knows and understand basics and recent developments of quantum thermodynamics (K_K01, K_W02, K_W06

## Skills

U01: Students is proving certain properties of quantum dynamical systems (K_U01K_U02)
U02: Student can formulate problems in the theory quantum dynamics and open systems properly using mathematical formalism (K_U02)
U03: Student is able to work within the project (K_U09)

## Social competence

K01: The student is aware that working in a team is responsible for the success of the project (K_K03, K_K07)

| | |
|---|---|
| K_K07<br>The student is aware of the responsibility for jointly (team) research tasks | |

**Contact**

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