Course title **Paradoxes of quantum mechanics**	**ECTS code** 13.2.0418

Name of unit administrating study
Department of Mathematics, Physics and Informatics

Studies

Faculty	**Field of study/ phd studies/doctoral school/postgraduate studies**	**Type**	**Form**
Quantum Information Technology	MSc studies	stationary	

Teaching staff
prof. dr hab. Michał Horodecki

Forms of classes, the realization and number of hours	**ECTS credits**
A. Forms of classes, in accordance with the UG Rector's regulations **Lecture**	**2 ECTS**
B. The realization of activities **classes in the teaching room of the University of Gdańsk** **blended learning**	
C. Number of hours **Lecture: 15**	

The academic cycle
According to study program

Type of course	**Language of instruction**
mandatory	**English**

Teaching methods
problem lecture
lecture with multimedia presentation

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

A. Final evaluation, in accordance with the UG study regulations
Credit with grade

B. Assessment methods
Test. Students will be asked to describe paradoxes, and perform relevant proof or calculation

C. The basic criteria for evaluation or exam requirements

Half of maximal number of points is needed to pass the exam

D. Method of verification of the established effects of education

established effect of education	exam
W01	+
W02	+
W03	+
U01	+
U02	+

Required courses and introductory requirements

A. **Formal requirements**
none

B. **Prerequisites**
knowledge on linear algebra, (quantum mechanics course welcome, but not necessary)

Aims of education

Basic knowledge about striking quantum mechanical effects that contradict "classical" common sense.

Course contents

During the course, basic quantum paradoxes will be presented:

1) **quantum interference and superposition, quantum eraser**
2) **uncertainty principle (measurement one and preparation one)**
3) **no-cloning, its relation with uncertainty**
4) **quantum teleportation and dense coding. Theoretical scheme and experimental realizations**
5) **Elitzur-Vaidman bomb tester**
6) **Entanglement, and Schrodinger paradox**
7) **local realism, GHZ paradox**
8) **Bell inequalities, nosignaling boxes and monogamy of quantum (and -supraquantum) correlations**
9) **contextuality and Peres-Mermin paradox**
10) **applied philosophy: communication complexity from Bell inequalities**

Bibliography of literature

A. **Literature required to pass the course**
- **Literature: Nielsen and Chuang, Quantum Computation and Quantum information;**
- **John Preskill, Lecture notes;**
- **John Watrous, Lecture notes;**
- **Buhrman et al, Non-locality and communication complexity, https://arxiv.org/abs/0907.3584v1**

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

Knowledge
- W01: Student knows basic quantum mechanical paradoxes (K_W01, K_W06)
- W02: Student understand main features of quantum fenomena and knows the diffreneces to classical mechanics (K_W01, K_W04)
- W03: Student knows the basic mathematical tools used in quantum mechanics (K_W02, K_W03)

Skills
- U01: students will be able to derive the paradoxes basing on quantum formalism (K_U01)
- U02: Students can prove basic results concerning paradoxes of quantum mechanics (K_U02)

Social competence

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*	

Contact
michal.horodecki@ug.edu.pl