University of Gdańsk

Subject card

Subject name and code	Quantum Information, PG_00158053						
Field of study	Quantum Information Technology						
Date of commencement of studies	October 2024		Academic year of realisation of subject	2025/2026			
Education level	Master's studies		Subject group				
Mode of study	full-time studies		Mode of delivery	at the university			
Year of study	2		Language of instruction	English			
Semester of study	4		ECTS credits	6.0			
Learning profile	academic		Assessment form				
Conducting unit	Faculty of Mathematics, Physics and Informatics -> Rector						
Name and surname of lecturer (lecturers)	Subject supervisor		prof. dr hab. Harald Weinfurter				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours	Self-study	SUM	
	Number of study hours	60		0.0	30.0	90	
Subject objectives	After completing the course the student should be able to understand basic quantum communication methods and their relation to conventional communication systems, as well possible applications in quantum networks like distributed computation, efficient communication, scheduling, voting etc.						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[QITL3_U01] is able to apply the scientific method in solving physical problems and reasoning in the field of quantum information theory	Student can perform evaluation of security proofs and reliability of distilling secure key based on observed detection events.	[SU4] test/exam - oral or written
[QITL3_W06] has knowledge of current directions in the development of physics, in particular in the field of quantum information theory	Student understand applications of quantum networks like distributed computation, efficient communication, scheduling, voting.	[SW4] test/exam - oral or written
[QITL3_W03] knows advanced experimental, observational and numerical techniques allowing to plan and perform a complex physical experiment or computer simulation	Student understands the basic components in quantum communication implementations like laser diodes, generation of entangled photons, single photon detectors, coherent detection methods, quantum memories and systems suitable to implement quantum logic operations.	[SW4] test/exam - oral or written
[QITL3_W04] knows advanced methods of theoretical and mathematical physics necessary in creating models of quantum mechanics	Students understand basic quantum logic gate operations required, e.g., for entanglement purification and Bell state analysis.	[SW4] test/exam - oral or written
[QITL3_W01] has extended knowledge in the field 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, knowledge of the world and social development	Student knows the history of quantum communication methods.	[SW4] test/exam - oral or written
[QITL3_K02] is aware of the decisive role of experiment in the verification of physical theories; is aware of the existence of the scientific method in acquiring knowledge	Student is aware about technical challanges for certification of Bell non-locality,	[SK4] test/exam - oral or written

Subject contents

1. Intro and QM basics

2. Quantum cryptography (quantum key distribution)

3. Quantum communication with entangled quantum states quantum dense coding, quantum teleporation, quantum games

4. Quantum repeater and quantum networks entanglement swapping entanglement purification quantum repeater

5. Hardware/experiments/demonstrations single photon sources and detectors sources (and analyzer) for entangled states

6. QKD networks, entanglement distribution

Prerequisites and co-requisites

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
tutorial part: test	51.0%	50.0%
lecture part: exam	51.0%	50.0%

Recommended reading	Basic literature	C.E. Shannon, Prediction and Entropy of Printed English, The Bell System Technical Journal 30, 1951 C.H. Bennett et al., Experimental Quantum Cryptography, Journal of Cryptology 5, pp. 3-28, 1992 J.P. Convey et al., Quantum networks with neutral atom processing nodes, npj Quantum Information 9, 90, 2023 S. Pirandola et al., Advances in quantum cryptography, Advances In Optics and Photonics 12, 1012, 2020
	Supplementary literature	None.
	eResources addresses	Adresy na platformie eNauczanie:
Example issues/ example questions/ tasks being completed		
Work placement	Not applicable	

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