RTU Course "Quantum Communication"

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General data

Code	RDE714
Course title	Quantum Communication
Course status in the programme	Compulsory/Courses of Limited Choice; Courses of Free Choice
Responsible instructor	Oskars Ozoliņš
Academic staff	Vjačeslavs Bobrovs Sandis Spolītis
Volume of the course: parts and credits points	1 part, 6.0 Credit Points, 9.0 ECTS credits
Language of instruction	LV, EN
Annotation	Today, quantum science has gone so far that several concepts of quantum information networks have already been implemented in the world, such as DARPA QKD, SECOQC Vienna, Tokyo QKD, Geneva area network, QUESS China, and others. Quantum photonics, shortly, will undoubtedly move from scientific laboratories to innovative cryptographic communication technologies, because the speed of photon propagation is the speed of light and photon coding can be realized in different states of frequency, phase, amplitude, polarization, and time. Besides, existing fibre optic transmission systems can provide part of the technological infrastructure required for future quantum communications. Within the study course, students will gain knowledge about quantum information transmission, quantum keys, quantum communication protocols, and the possible engineering infrastructure of the future quantum Internet.
Goals and objectives of the course in terms of competences and skills	The aim of the study course is to provide knowledge about quantum information transmission, quantum keys, quantum transmission protocols, system elements, and their application in quantum fibre optical communications. Tasks of the study course: • to provide basic knowledge and experience about quantum fibre optical communications; • to teach to develop and apply simple quantum algorithms for quantum signal processing; • to provide students with an idea in the experimental laboratory about the actual quantum transmission; • to develop skills to evaluate the existing communication system infrastructure for the further implementation of quantum photon transmission.
Structure and tasks of independent studies	Within the study course, students' independent work will be organized as follows: - to solve the tasks defined by the academic personnel, showing the use of the knowledge acquired in the lectures, - summarize and analyse the latest published research results on quantum communications, - applying the acquired theoretical knowledge a mathematical model of the quantum communication system should be created in the modelling environment, - an experimental quantum communication system should be developed based on the equipment available in the research laboratory.
Recommended literature	Obligātā/Obligatory: Yu-Ao Chen u.c. An integrated space-to-ground quantum communication network over 4,600 kilometres. Nature, 2021 Daniele Cozzolino, Beatrice Da Lio, Davide Bacco,Leif Katsuo Oxenløwe. High-Dimensional Quantum Communication: Benefits, Progress, and Future Challenges. Advanced Quantum Technologies, 2019 Jianwei Wang, Fabio Sciarrino, Anthony Laing, Mark G. Thompson. Integrated photonic quantum technologies. Nature Photonics, 2019 Cariolaro, Gianfranco. Quantum Communications. Springer International Publishing, 2015 Papildu/Additional: R. Lin, A. Udalcovs, O. Ozolins, M. Tang, S. Fu, S. Popov, T. Ferreira da Silva, G. B. Xavier, and J. Chen. Embedding Quantum Key Distribution into Optical Telecom Communication Systems. IEEE, 2019 R. Lin, A. Udalcovs, O. Ozolins, X. Pang un citi. Telecommunication Compatibility Evaluation for Co-existing Quantum Key Distribution in Homogenous Multicore Fiber. IEEE Access, 2020 R. Lin, A. Udalcovs, O. Ozolins, X. Pang, L. Gan, L. Shen, M. Tang, S. Fu, S. Popov, C. Yang, W. Tong, D.Liu un citi. Telecom Compatibility Validation of Quantum Key Distribution Co-existing with 112 Gbps/core Data Transmission in Non-Trench and Trench-Assistant Multicore Fibers. IEEE, 2018 Mario Krenn, Mehul Malik, Thomas Scheidl, Rupert Ursin, Anton Zeilinger. Quantum communication with photons. Springer International Publishing, 2016 Sandor Imre, Laszlo Gyongyosi. Advanced Quantum Communications: An Engineering Approach. Wiley-IEEE Press, 2012
Course prerequisites	Fibre Optic Transmission Systems, Digital Optical Communication Systems, Physics of Optical Information Processing.

Course contents

Content	Full- and part-time intramural studies		Part time extramural studies	
	Contact Hours	Indep. work	Contact Hours	Indep. work

Introduction to quantum communication.	4	6	0	0
Comparison of classical and quantum communication.	8	12	0	0
Quantum technologies for quantum information processing.	8	12	0	0
Quantum communication protocols.	8	12	0	0
Quantum sources and detectors.	4	6	0	0
Two-photon quantum interference and entanglement.	8	12	0	0
Quantum mixed states.	8	12	0	0
Quantum compression.	8	12	0	0
Quantum communication systems with OOK, BPSK, QAM, PSK, and PPM modulation formats.	16	24	0	0
Practical and experimental works in the transmission of binary and multilevel quantum states in a teaching-scientific laboratory.	24	36	0	0
Total:	96	144	0	0

Learning outcomes and assessment

Learning outcomes	Assessment methods
Able to competently explain quantum fibre optical communications, know the basic parameters and structure of the main elements.	Test. Exam questions.
Able to create simple quantum algorithms for processing quantum signals and incorporate them into quantum photon communications.	Test. Practical works. Exam questions.
Can evaluate the impact of linear effects and noise in quantum signal transmission.	Test. Practical works. Exam questions.
Able to develop a quantum communication system in a teaching-scientific laboratory. Able to use different types of quantum photon sources and receivers, as well as to evaluate the applicability of the chosen modulation format in signal transmission.	Test. Practical and laboratory work. Exam questions.

Evaluation criteria of study results

Criterion	%
Tests	40
Laboratory and practical works	30
Exam	30
Total:	100

Study subject structure

Part	CP	Hours per Week			Tests			Tests (free choice)		
		Lectures	Practical	Lab.	Test	Exam	Work	Test	Exam	Work
1.	6.0	2.0	2.0	2.0		*			*	