Subject card

Subject name and code	Quantum Optics, PG_00159205						
Field of study	Quantum Information Technology						
Date of commencement of studies	October 2026		Academic year of realisation of subject		2026/2027		
Education level	Master's studies		Subject group				
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	1		Language of instruction		English		
Semester of study	2		ECTS credits		6.0		
Learning profile	academic		Assessment form		exam		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr Konrad Schlichtholz				
	Teachers		dr Konrad Schlichtholz Anuradha Tonipe				
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	The aim of this lecture is to introduce various concepts and mathematical tools of quantum optics necessary in contemporary research in the field of optical quantum technologies.						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[QITL3_W02] knows and understands on deepened level key and selected advanced detailed issues in the field of quantum information technology, including methods of their research and development, and their applications in the context of dynamic technological changes, in particular in the area of information processing, cryptography and the development of advanced computing systems	The student has an advanced understanding of quantum optics phetnomena and their applications in quantum information processing, quantum communication, quantum metrology, and quantum computing.	[SW4] test/exam - oral or written
[QITL3_W01] knows and understands in depth selected facts, objects and phenomena, as well as the methods and theories related to them, explaining the complex relationships between them, constituting advanced general knowledge in the field of quantum information technology, as well as the scientific research methodology specific to this discipline and its importance in the context of contemporary directions of development of science and technology	The student has an advanced understanding of the phenomena, models, and methods of quantum optics, including the quantization of the electromagnetic field, light–matter interaction, and nonclassical states of light	[SW4] test/exam - oral or written

Subject contents	-Second quantization -Fock space representation of states -Phase-space methods for description of states -Gaussian and non-Gaussian states and operations -Interferometry -Field-matter interaction -Non-linear quantum optics -Entanglement in quantum optics -Information encoding in continuous and discreet variables -Universal quantum computing in quantum optics -Metrology in optical systems
Prerequisites and co-requisites	

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
exam	51.0%	50.0%
passing tutorials	51.0%	50.0%

Recommended reading

Basic literature	Introductory Quantum Optics. Christopher C. Gerry & Peter L. Knight (2004). Introductory Quantum Optics. Cambridge: Cambridge University Press. ISBN: 978-0-521-52735-4. Mathematical Methods of Quantum Optics. Ravinder R. Puri (2001). Mathematical Methods of Quantum Optics. Berlin: Springer. (Springer Series in Optical Sciences, Vol. 79). ISBN: 978-3-540-41704-0. Quantum Optics. Stanisław Kryszewski (2010). Quantum Optics. Gdańsk: University of Gdańsk. Lecture notes (237 pp.).
Supplementary literature	none
eResources addresses	

Example issues/ example questions/ tasks being completed	1. Quantization of the Electromagnetic Field and State Representations • Second quantization of the electromagnetic field. • Creation and annihilation operators and their properties. • Fock space, number states, coherent states, and thermal states. • Physical interpretation of the photon number. 2. Phase-Space Representation of Optical States • Wigner, Husimi (Q), and Glauber–Sudarshan (P) functions. • Relationships between phase-space representations. • Characteristics of Gaussian and non-Gaussian states. • The significance of the negativity of the Wigner function as an indicator of nonclassicality. 3. Light–Matter Interaction and Nonlinear Quantum Optics • The Jaynes–Cummings model. • Spontaneous and stimulated emission. • Spontaneous parametric down-conversion (SPDC) and four-wave mixing. • Generation of squeezed light and entangled states. 4. Entanglement and Quantum Information Processing with Light • Entanglement in optical systems. • Information encoding using discrete-variable and continuous-variable systems. • Linear optical quantum gates and the KLM scheme. • Universal quantum computing with optical systems. 5. Interferometry and Quantum Metrology • Mach–Zehnder and Michelson interferometers. • The Standard Quantum Limit (SQL) and the Heisenberg limit. • The use of squeezed and entangled states to enhance measurement sensitivity. • Applications of quantum metrology in optical measurements and quantum sensing.
Work placement	Not applicable