Subject card

Subject name and code	Coherence and Decoherence in Superconducting Qubits, PG_00165986						
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	3		ECTS credits		6.0		
Learning profile	academic		Assessment form		exam		
Conducting unit	Faculty of Mathematics, Physics and Informatics -> Rector						
Name and surname of lecturer (lecturers)	Subject supervisor		dr Andre Hernandes Alves Malavazi				
	Teachers		dr Andre Hernandes Alves Malavazi mgr Aravinth Ravichandran				
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 the course is to provide a contemporary knowledge in the field of superconducting qubits both from theoretical and experimental point of view. The course explains how the quantum coherence is created, manipulated, and measured in superconducting qubits.Different methods to protect the system from decoherence to extend the qubit lifetime are presented. The course provides an introduction to one of the most prominent physical realization of quantum computing.						

Learning outcomes

Course outcome	Subject outcome	Method of verification
[QITL3_W03] knows advanced experimental, observational and numerical techniques allowing to plan and perform a complex physical experiment or computer simulation	Student understands experimental methods enabling qubit implementation in superconducting circuits	[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 experiments testing assumptions made for modelling noisy superconducting circuits	[SK4] 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 understands physical mechanism of superconductivity.	[SW4] test/exam - oral or written
[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 assesment of experimental viability of a given quantum protocol in current superconducting technology	[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 is aware about popular architectures and parameters of quantum computers based on superconducting quantum circuits	[SW4] test/exam - oral or written
[QITL3_W02] has in-depth knowledge in the field of advanced mathematics and mathematical and computer methods, necessary to solve physical problems of medium complexity, and advanced knowledge in the area of quantum information and its technological aspects	Student is aware about numerical methods used in simmulations of superconducting circuits.	[SW4] test/exam - oral or written
[QITL3_U05] has the ability to synthesize methods and ideas from various areas of physics and other branches of science; is able to notice that distant phenomena are sometimes described by similar models	Student understands mathematical and physical simmilarities between superconductivity and superfluidity,	[SU4] test/exam - oral or written

Subject contents

1. Concept of the quantum coherence (free evolution, self-frequency, interference)
2. Two-level system and quantum coherence realized by weakly coupled superconductors
3. Coherent operations and measurements (single-body gates, Rabi and Ramsey interferometry)
4. Concepts of the dissipation and decoherence
5. Dissipation and decoherence in two-level system (phenomenology, Bloch equations)
6. Master equation (derivation and applications)
7. Noise in superconducting qubits (power spectral density, pure decoherence models)
8. Coherence protection (dynamical decoupling, insensitivity to noise, noise reduction)
9. Qubit measurement and application of two-body gates

Prerequisites and co-requisites

Assessment methods and criteria

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

Recommended reading

Basic literature	1. Quantum mechanics : a modern development / Leslie E. Ballentine. 2. The Theory of Open Quantum Systems /Heinz-Peter Breuer, Francesco Petruccione 3. A quantum engineer's guide to superconducting qubits / P. Krantz et al.
Supplementary literature	None.

	eResources addresses	
Example issues/ example questions/ tasks being completed		
Work placement	Not applicable	

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