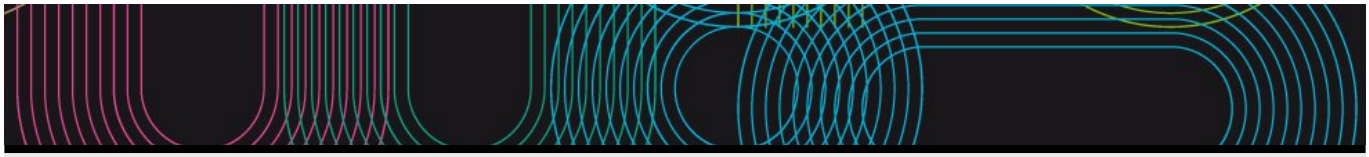
Universidade Vigo

Subject Guide 2023 / 2024



IDENTIFYING DATA				
Advanced Quantum Information Theory				
Subject	Advanced Quantum Information Theory			
Code	V05M198V01109			
Study programme	(*)Máster Universitario en Ciencia e tecnoloxías de información cuántica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	3	Optional	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Fernández Veiga, Manuel			
Lecturers	Díaz Redondo, Rebeca Pilar Fernández Veiga, Manuel			
E-mail	mveiga@det.uvigo.es			
Web				
General description	(*)Este curso presenta, interpreta e aplica os resultados principais da teoría da información cuántica aplicables á transmisión e a compresión de información cuántica.			

Training and Learning Results	
Code	
A3	Understanding and knowledge of the fundamentals of Quantum Information Theory, as well as two basic aspects of two four types of quantum technologies: computing, communications, metrology, simulation.
A11	Acquiring a solid foundation on quantum theory gives information on its application in quantum communications, as well as on the technology of two photonic devices used in quantum communications, both terrestrial and aerial and via satellite.
B3	To know the physical bases that allow encoding and processing information. Understanding of the new rules that Quantum Mechanics imposes for its processing.
B13	To be aware of the physical and technical limitations of the implementation of quantum information treatment systems: noise, decoherence, etc., as well as the mitigation or correction strategies that are proposed.
D1	Acquisition of tools and knowledge that allow the development of original and innovative ideas in a business or academic context.
D2	Ability to solve problems in new or little familiar contours within broader (or multidisciplinary) contexts related to their area of study.
D3	Ability to integrate knowledge and deal with complexity before making judgments based on information that, being incomplete or limited, includes reflections on social and ethical responsibilities.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Knowledge and ability to apply known results in Quantum Information Theory to problems, and to develop new results on Quantum Information Theory as well	A3 A11 B3 B13 D1 D2 D3

Contents
Topic

1. Quantum channels	a. Review of characterizations of quantum channels: natural, Choi, Kraus, Stinespring b. Examples of channels: preparation, addition, substitution, classical-quantum, quantum-classical, isometric, depolarization, erasure c. Until channels: mixed initial channels, Weyl channels, Schur channels d. Separable channels, separability measures. PPT channels. LOCC channels.
2. Entanglement-assisted classical communications	a. One-shot channel capacity. Bounds b. Asymptotic channel capacity c. Examples
3. Classical communications over quantum channels	a. One-shot channel capacity. Bounds b. Asymptotic channel capacity c. Examples
4. Quantum communications over quantum channels	a. One-shot channel capacity. Bounds b. Asymptotic channel capacity c. Examples

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	25	43
Problem solving	5	0	5
Problem and/or exercise solving	0	25	25
Essay questions exam	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation of theory, scientific results, and examples about quantum communications and quantum protocols.
Problem solving	Practice sessions for problem solving. Also, homework problem sets, to be solved individually by students and returned for grading and assessment.

Personalized assistance

Methodologies	Description
Lecturing	Individual tutoring sessions will be offered to students, covering all the theoretical aspects of the course. Office hours and type of meetings: Manuel F. Veiga. [https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga] Rebeca Díaz. [https://moovi.uvigo.gal/user/profile.php?id=11470]
Problem solving	Individual tutoring sessions will be offered to students as assistance for understanding the models and problem solving techniques related to the course topics. Office hours and type of meetings: Manuel F. Veiga. [https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga] Rebeca Díaz. [https://moovi.uvigo.gal/user/profile.php?id=11470]

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	Homework problem sets to be solve individually, written and graded. Two sets of problems with 30% of the final grade each.	60	A3 A11	B3 B13	D1 D2 D3
Essay questions exam	Written exam. Problems.	40	A3 A11	B3 B13	D1 D2 D3

Other comments on the Evaluation

There will be two evaluation modalities in the ordinary call: continuous evaluation and global evaluation. The continuous evaluation consists of the delivery of two sets of written exercises resolved individually by each student, each of which will have a weight of 30% in the final grade, plus a written exam at the end of the course, with a weight of 40%. . The overall evaluation will consist of a single written exam at the end of the course. A student will be considered as opting for the overall assessment if they do not submit the first set of written exercises. The continuous evaluation prevents a final qualification of not presented.

Sources of information

Basic Bibliography

John Watrous, **The theory of quantum information**, Cambridge University Press, 2018

Complementary Bibliography

Sumeet Khatri and Mark M. Wilde, **Principles of Quantum Communication Theory: A Modern Approach**, 2021

Michael A. Nielsen & Isaac L. Chuang, **Quantum Computation and Quantum Information**, Cambridge University PRess, 2011

Recommendations