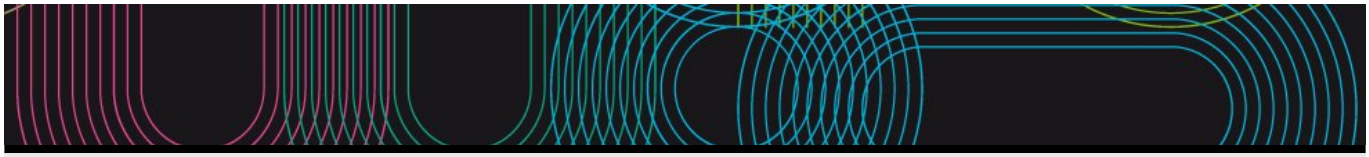

IDENTIFYING DATA				
Bug fixing code				
Subject	Bug fixing code			
Code	V05M198V01203			
Study programme	(*)Máster Universitario en Ciencia e tecnoloxías de información cuántica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	3	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fernández Veiga, Manuel			
Lecturers	Fernández Veiga, Manuel			
E-mail	mveiga@det.uvigo.es			
Web	http://quantummastergalicia.es			
General description	Basic theory and applications in computing and communications of quantum error control codes			

Training and Learning Results	
Code	
A13	Know the strategies of quantum cryptography and its feasibility and solvency in the context of the quantum internet, the quantum chain of blocks and secret communications, acquiring a panoramic vision of two actors that will be essential in their deployment.
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.
C1	To analyze and break down a complex concept, examine each part and see how they fit together
C2	To classify and identify types or groups, showing how each category is different from the others
C3	To compare and contrast and point out similarities and differences between two or more topics or concepts

Expected results from this subject	Training and Learning Results
Ability to understand the construction, analysis and applications of quantum error control codes in communication systems and quantum computers. Knowledge of the main specific codes	A13 B13 C1 C2 C3

Contents	
Topic	
Module 1: Quantum Errors	Overview of quantum errors and their sources. Decoherence and noise in open quantum systems Quantum error models and error types. Digitization of quantum noise. Error operators.
Module 2: Fundamentals of Quantum Error Correction	From classical to quantum error correction The three-qubit error correction code The nine-qubit Shor code Quantum error correction conditions The quantum Hamming bound
Module 3: Constructing quantum codes	Classical linear codes Calderbank-Shor-Steane (CSS) codes

Module 4: Stablizer codes	□ The stabilizer formalism □ Measurement in the stabilizer formalism □ Stabilizer code constructions □ Quantum circuits for encoding, decoding and correction
Module 5. Topological stabilizer codes	· Z2 chains - Surface codes on a torus · Planar surface codes · Topological quantum error correction
6. Fault-tolerant quantum computing	· Fault tolerance in quantum computing · Fault-tolerant quantum error correction · Coded operations with fault tolerance

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	23	41
Problem solving	5	15	20
Problem and/or exercise solving	0	12	12
Presentation	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	The main elements of quantum error codes, their applications and limitations will be presented.
Problem solving	Typical quantum error code design and analysis problems will be solved, in order to learn how to use the methods seen in the lectures.

Personalized assistance

Methodologies	**Description**
Lecturing	Support will be offered during tutoring hours and by e-mail. For contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga
Problem solving	Support will be offered during tutoring hours and by e-mail. For contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga
Tests	**Description**
Problem and/or exercise solving	Support will be offered during tutoring hours and by e-mail. For contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	Two homework problems sets throughout the course period, 30% each. Individual written submissions.	60	A13	B13	C1 C2 C3
Presentation	Presentation of an essay	40	A13	B13	C1 C2 C3

Other comments on the Evaluation

Two modes of evaluation are offered, continuous evaluation and global evaluation.

The continuous evaluation consists of a written exam at the end of the course (40%) plus two individual exercise resolution tests (30% each). The global evaluation consists of a single exam at the end of the course. A student opts for continuous evaluation if he/she submits any of the exercise resolution tests. Continuous evaluation never results in a grade of "not presented".
In the extraordinary exam the same evaluation system will be used, at the choice of each student.

Sources of information

Basic Bibliography

M. A. Nielsen, I. L. Chuang, **Quantum Computation and Quantum Information**, Cambridge University PRess, 2010

Complementary Bibliography

Giuliano Gadioli La Guardia, **Quantum Error Correction Symmetric, Asymmetric, Synchronizable, and Convolutional Codes**, https://doi.org/10.1007/978-3-030-48551-1, Springer, 2020

Frank Gaitan, **Quantum Error Correction and Fault Tolerant Quantum Computing**, 9780849371998, Routledge - Taylor & Francis, 2013

D. A. Lidar, T. A. Brun, **Quantum Error Correction**, https://doi.org/10.1017/CBO9781139034807, Cambridge University Press, 2013

Recommendations