COM-611

Quantum Information Theory and Computation

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Cursus	Sem.	Type
Computer and Communication Sciences		Opt.
Photonics		Opt.

Language of teaching	English
Credits	4
Session	
Exam	Oral
Workload	120h
Hours	**56**
Lecture	28
Exercises	28
Number of positions	

Remark

Not offered this year

Summary

Today one is able to manipulate matter at the nanoscale were quantum behavior becomes important and possibly information processing will have to take into account laws of quantum physics. We introduce concepts developed in the last 25 years to take advantage of quantum resources.

Content

Part I. A primer on Quantum Mechanics and Qubits.
Quantum bits.
Interference experiments with photon polarisation, spin; Superposition principle; Measurement postulate;
Basic principles of quantum mechanics in finite Hilbert spaces.
Many Qubit states.
Entanglement; Bell inequalities and EPR paradox; No cloning; Quantum key distribution; Quantum teleportation.
Part II. Quantum Information Theory.
Von Neumann Entropy and Mutual Information.
Density matrix and mixed states; Von Neumann entropy; Subadditivity; Araki-Lieb lower bound; Mutual information.
Quantum data compression.
Schumacher compression; Compression of mixed states and Holevo bound.
Noisy Quantum Channels.
Channel models; Capacity results.
Part III. Quantum Computation.
Basic ideas behind the Quantum Computer.
Feynman and Deutsch point of view; Unitary evolution and quantum parallelism; Quantum circuits;
Universal elementary gates; Quantum Fourier transform and its circuit.
Quantum Algorithms.
Deutsch-Josza problem; Grover search algorithm; Shor algorithm for the period of a function;
Application to factoring and cryptography.
Quantum Error Correcting Codes (if time permits)

Learning Prerequisites

Required courses

Linear algebra.

Recommended courses

Linear Algebra and Basic Information Theory. No prerequisite in quantum mechanics will be needed.

Important concepts to start the course

Matrix and vector calculus, inner product, complex numbers.

Learning Outcomes

By the end of the course, the student must be able to:

- Master the basic principles of quantum computation and information theory.
- Be able to state the main differences between classical and quantum concepts related to computation, information and correlations .

Teaching methods

Ex-Cathedra. Homeworks.

Expected student activities

Participation in class and homeworks.

Assessment methods

Homeworks + oral exam

Resources

Bibliography

Nielsen and Chuang: Quantum Information and Computation. CUP.

Ressources en bibliothèque

- Quantum information and computation / Nielsen

Notes/Handbook

Class notes.

Websites

- http://ipg.epfl.ch/doku.php?id=en:courses