UE Quantum Information & Dynamics

Niveau d'étude Bac +5	ECTS 6 crédits	Crédits ECTS Echange 6.0	Composante UFR IM2AG (informatique, mathématiques et mathématiques appliquées)	Période de l'année Automne (sept. à dec./janv.)

- **Langue(s) d'enseignement:** Anglais
- **Ouvert aux étudiants en échange:** Oui
- **Crédits ECTS Echange:** 6.0
- **Code d'export Apogée:** GBX9AM88

Présentation

Description

The quantum formalism developed a century ago provides a very precise description of nature at small scales which entails several counter intuitive aspects: superposition of states, entanglement, intrinsic randomness of measurement process, to list a few. However, from a mathematical point of view, quantum mechanics does have a definite formulation. This allows to investigate these intriguing features rigorously and to explore these quantum traits in information theory and algorithmics in particular, as well as the challenges they present.

The goal of these lectures is to provide a mathematical description of the quantum formalism in finite dimension and to introduce the mathematical concepts and tools required for the analysis of such quantum systems and their dynamics. On the one hand, we will study the key aspects of quantum information theory. On the other hand, we will describe certain properties of quantum dynamics that need to be taken into account in the implementation of quantum algorithms and that will be applied to emblematic systems. The interaction with an external classical electromagnetic field will also be considered both from a theoretical and a numerical point of view.

Heures d'enseignement

CM	CM	36h

Pré-requis recommandés

Linear Algebra, Analysis, ODE theory (master 1 level)

Syllabus

Part I (9 hours) A. Joye : Quantum formalism and Functional analysis in finite dimension

- Quantum states, observables, quantum measurement process.
- Spectral theorem, functional calculus, Klein's inequality
- Entropies, Gibbs state, variational principle.

Part II (9 hours) C. Lancien : Quantum Information

- Multipartite quantum systems: tensor product spaces, partial trace
- Entanglement characterization and detection: Schmidt decomposition, entanglement witnesses, entanglement criteria
- Quantum channels: representations, output entropies
- Quantum information: no-cloning theorem, additivity problems, quantum algorithms

Part III (9 hours) A. Joye : Quantum Dynamics of Open Systems

- Quantum trajectory and associated Markov process
- Discrete and continuous in time Quantum dynamics, decoherence
- Quantum master equation, Markovian approximation, Lindblad dynamics

Part IV (9 hours including 3 hours of practical sessions in Python) B. Bidegaray, C. Jourdana : ODE-PDE modeling and numerical analysis in quantum optics

- Numerical resolution of the Lindblad equation (conservation of the physical properties, splitting methods).
- Maxwell-Bloch model (Maxwell equations, coupling with Bloch equations, Cauchy problem).
- Numerical resolution of Maxwell-Bloch equations (finite difference scheme on staggered grids, stability analysis).

Infos pratiques

Contacts

Responsable pédagogique

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Campus

- Grenoble - Domaine universitaire