UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Quantum Simulation

2627-2-F9103Q048

Aims

This course will provide the theoretical tools for the analysis and the optimisation of quantum information processing tasks (e.g. cloning, estimation, discrimination) and for the study and the simulation of quantum many body systems.

Contents

First, we will introduce the fundamentals notions of quantum information processing along with the needed mathematical tools. Then, we will study the more general case of multi-round quantum protocols. Finally, we will discuss quantum many body systems on a lattice, focusing on Quantum Cellular Automata and Tensor Networks.

Detailed program

- The church of the larger Hilbert space: Stinespring dilation theorem and Choi-Jamiolkowsky isomorphism.
- Quantum information processing: estimation, discrimination, tomography, cloning and teleportation.
- Multi-round protocols and quantum strategies: network of quantum operations and quantum combs, optimisation problems and semidefinite programming, fully quantum machine learning.
- Quantum Cellular Automata and quantum walks: fundamental definitions, structure theorems, applications, experimental implementations.
- Tensor networks: fundamental definitions, application to quantum simulation of many body systems (Matrix Product States and Density Matrix Renormalisation Group).

Prerequisites

Linear algebra, quantum physics, fundamental notions of quantum computing and quantum information.

Teaching form

The course is organised with blackboard lectures, where all the details and tools necessary to the understanding of the topics will be properly addressed, with the aim of stimulating an interactive atmosphere with the students.

Textbook and teaching resource

J. Watrous
“The Theory of Quantum Information”
Cambridge University Press (2018).

J. Ignacio Cirac, David Pérez-García, Norbert Schuch, and Frank Verstraete
"Matrix product states and projected entangled pair states: Concepts, symmetries, theorems"
Rev. Mod. Phys. 93, 045003 (2021)

Lecture notes and bibliographic references provided by the teacher

Semester

first

Assessment method

The exam consists of an oral test aimed at verifying the ability of the student to present rigorously and with an appropriate technical language all concepts learned.

Office hours

Alessandro Bisio will receive by appointment via email.

Sustainable Development Goals