UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Quantum Simulation

2223-1-F9102Q024

Aims

The aim of this course consists of enabling to identify which architecture (gate model, adiabatic, measurement based) of quantum computer is most suitable for solving a given problem and to program simulators of quantum computers and actual quantum computers. Fundamental of quantum algorithms and their applications including quantum chemistry and quantum neural networks are introduced.

Contents

The mathematical tools of quantum mechanics relevant for quantum computing are introduced, together with their connection with actual up to date harware. Next, a list of quantum algorithm with actual implementation are introduced, for gate model quantum computers, adiabatic quantum computers and measurement based quantum computers. Practical examples of implementations of algorithms are developed during the laboratory activity.

Detailed program

The Qubit: Bloch Sphere and Single Qubit Rotations, Two qubits gates, Entanglement,, Physical implementation (Superconducting, Ions, Photonic Qubits), Architectures: Gate model, Adiabatic Quantum Computer, Measurement based (or One Way) Quantum Computer. Fundamental Algorithms: Search Algorithms, Quantum Fourier Transform and Shor, Quantum annealing algorithms, Variational quantum algorithms: Variational Quantum Eigensolver, Variational Linear Systems Solver, Quantum Boltzmann machine, Introduction to Quantum Chemistry, Quantum Neural Networks

Prerequisites

Linear algebra, Dirac notation of quantum mechanics, unitary operators, Ising model (from the “AI models for Physics” Course, held during the same semester).

Teaching form

Lectures and laboratory programming activity. Both of them will be held in presence, unless further COVID-19 related restrictions are imposed. Attendance both to lectures and practical examples is warmly recommended.
The programming activity refers to the program by computational lessons in which students can simulate the models. The computational part will take place in Python.

Textbook and teaching resource

Nielsen and Chuang “Quantum Computation and Quantum Information”
Rieffel and Polack “Quantum Computing a Gentle Introduction"

Semester

Second

Assessment method

Students are required to prepare a written report on one of the laboratory activities, the exam will then consist in oral questions on the topics covered during lectures.

Office hours

Wednesday 17-18

Sustainable Development Goals

INDUSTRY, INNOVATION AND INFRASTRUCTURE