Quantum Computation (L16)

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Quantum mechanical processes can be exploited to design new modes of information processing that are beyond the capabilities of any classical computer. This leads to remarkable new kinds of algorithms (so-called quantum algorithms) that can offer a dramatically increased efficiency for the execution of some computational tasks. In addition to such potential practical benefits, the study of quantum computation has great theoretical interest, combining concepts from computational complexity theory and quantum physics to provide striking fundamental insights into the nature of both disciplines.

This course will be a 'second' course in the subject, following the Part II course Quantum Information and Computation (see below in prerequisites) that was introduced in 2017-2018.

In this course we will aim to cover the following topics:

- The hidden subgroup problem and quantum Fourier transform on a group;
- The quantum phase estimation algorithm and applications;
- Amplitude amplification and applications;
- Quantum simulation of time evolution under local hamiltonians.

Depending on the availability of time, we will then cover a selection of the following topics:

- The Harrow-Hassidim-Lloyd algorithm for solving a system of linear equations;
- The Quantum Singular Value Transformations toolkit and applications;
- Introduction to Clifford operations and Stabilizer formalism; classical simulation properties of Clifford circuits (Gottesman-Knill theorem).

Prerequisites

This course will assume a prior basic acquaintance with quantum computing, to the extent presented in the course notes for the Cambridge Part II course Quantum Information and Computation available at http://www.qi.damtp.cam.ac.uk/part-iii-quantum-computation

In particular you should be familiar with Dirac notation and principles of quantum mechanics, as presented in the course notes sections 2.1, 2.2 and 2.3. You should also have a basic acquaintance with quantum computation to the extent of the second half of the course notes, pages 47 to 86 (Chapters 6-11). It would be desirable for you to look through this material before the start of the course.

Literature

1. Michael Nielsen and Isaac Chuang, *Quantum Computation and Quantum Information.* CUP, 2000.
2. John Preskill, *Lecture Notes on Quantum Information Theory* (especially Chapter 6).
3. Ronald de Wolf, *Quantum Computing: Lecture Notes*.

Additional support

Three examples sheets will be provided and three associated examples classes will be given. There will be a one-hour revision class in the Easter Term.