Quantum Information

Stephen M. Barnett
Depratment of Physics, SUPA, University of Strathclyde, Glasgow G4 0NG, UK

Quantum information must be one of if not the most rapidly developing fields of physics. The last ten years have seen an explosion of interest in this topic and the recruitment of a great number of new researchers specializing in this area. But what is all the fuss about? In this course I aim to give an introduction to this multidisciplinary field. It is already impossible to cover the entire subject in any single course and so I shall concentrate primarily on the theoretical and conceptual foundations of the topic.

The course will follow rather closely my textbook *Quantum Information* (Oxford University Press, Oxford, 2009) and serious students will benefit from having a copy at hand during the course.

Following is a preliminary plan of the course. I say "preliminary" because I am expecting to make changes so as to match the background, requirements and special interests of those attending the lectures.

1. Probability and information
Introduction to the course, conditional probabilities, entropy and information, communications theory.

2. Elements of quantum theory
Basic principles, mixed states, unitary operators, qubits, entangled states

3 Quantum cryptography
Information security, quantum communications, optical polarization, quantum key distribution.

4. Generalized measurements
Ideal von Neumann measurements, non-ideal measurements, probability operator measures, optimized measurements, operations.

5. Entanglement
Non-locality, indirect measurements, ebits and shared entanglement, quantum dense coding, teleportation.

6. Quantum information processing
Digital electronics, quantum gates, quantum circuits, quantum error correction, cluster states.

7. Quantum computation
Elements of computer science, principles of quantum computation, the quantum Fourier transform, Shor's factoring algorithm, Grover's search algorithm, physical requirements.

8. Quantum information theory
The von Neumann entropy, composite systems, quantitative state comparison, measures of entanglement, quantum communications theory.