13936-746 (8) Quantum Optics and Quantum Information (1.5L, 1.5P)

2022

Course summary:

History of quantum optics and quantum information, quantum bits, photons, quantum communication, quantum computation, quantum algorithms, quantum Information, field quantization, coherent states, atom and field interactions, beam splitters and interferometers, optical tests of quantum mechanics, nonclassical light, cavity QED, measurements, entanglement, decoherence and noise, distance measures, quantum error correction, entropy and information, use of IBM quantum processors.

Module relevance in programme:

This course offers a comprehensive look at quantum information processing using light, with an emphasis on quantum computing and its optical implementation. The topics cover a mix of theoretical and experimental concepts. It is envisioned that the course permits a seamless transition of concepts to practice, which are the requirements of the various quantum research projects undertaken in Physics. The module requires some prior knowledge in classical electromagnetism, as presented in the undergraduate modules 254 and 342, and 711. Knowledge of quantum mechanics is also beneficial, as presented in the undergraduate modules 254 and 334, and 714.

Outcomes of course:

The outcomes of the course are to give the student an understanding of a number of quantum optical techniques that are available for quantum information processing.

The student should:

- understand the physical principles on which the techniques rely,
- be able to apply this knowledge to special cases related to research projects,
- have knowledge of how these techniques are applied in research and technology.

Lecturer:

Prof M S Tame
Telephone number: (021) 808-3375
E-mail address: mstame@sun.ac.za
Office: In the Merensky Physics Building

Mentor:

The Department of Physics has appointed a staff member as mentor for each year of its physics programme to be available to students for consultation. Students should feel free to discuss general issues related to the physics programme or specific modules in the programme with the relevant mentor, in addition to usual consultations with their individual lecturers of modules.

The mentor for the Honours programme and its modules is Dr Philip Southey southey@sun.ac.za.

Course content:

The following topics are covered during formal lectures:

INTRODUCTION: History of quantum optics and quantum information, quantum bits, photons,

quantum communication, quantum computation, quantum algorithms, quantum Information.
QUANTIZATION: Coherent states, atom and field interactions, beam splitters and interferometers, nonclassical light, cavity QED.
FOUNDATIONAL QUANTUM MECHANICS: Measurements, decoherence and entanglement.
QUANTUM INFORMATION: distance measures, quantum error correction, entropy and information.

Tutorials:

There are informal tutorial sessions, during which students have the opportunity to solve problems related to the course work with the assistance of the lecturer.

Study material:

Quantum Computation and Quantum Information, M A Nielsen and I L Chuang, Cambridge University Press – Cambridge, 2010.
Introductory Quantum Optics, C Gerry and P Knight, Cambridge University Press – Cambridge, 2005.

Learning opportunities:

Class discussions and tutorial problems.

Assessment:

Methods of Assessments
Tutorial problems, assignments and tests contribute to the continuous assessment.

Venue and time of assessment opportunities
Details will be communicated to students at start of module.