13937 - 773 (8) Non-linear Optics (1.5L, 1.5P)

2022

Course summary:

Principles of non-linear optics. Non-linear polarisation, non-linear optical coefficients, harmonic generation and phase matching.

Anisotropy, optical modulation: Electrooptical, magneto-optical and acousto-optical modulation.

Module relevance in programme:

The module builds on and extends the Optics module (Physics 772). With the widespread use of lasers nonlinear optics is the natural extension of optics, making technology such as optical fiber communication, miniaturization of electronics and accurate measurement of frequencies and time, and the realization of quantum computing possible

Outcomes of course:

The outcomes of the course are to give the student an understanding of a number of the optical techniques that are available in the application of lasers.
The student should:

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

Lecturer:

Prof EG Rohwer
Telephone number: +2721 8083372
E-mail address: egr@sun.ac.za
Office: Room 1003 in the Merensky Physics Building**)**

Dr CM Steenkamp
Telephone number: +2721 8083374
Email address: cmsteen@sun.ac.za
Office: Room 1044 in the Merensky 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 coordinator for the Honours programme and its modules is **Prof KK Müller-Nedebock** kkmn@.sun.ac.za and Dr Philip Southey southey@sun.ac.za is your mentor.

Course content:

1. INTRODUCTION: Nonlinear properties, processes and susceptibilities.

2. CLASSICAL THEORY OF NONLINEAR OPTICS: Lorentz model with anharmonic oscillators, properties of nonlinear susceptibilities.

3. QUANTUMMECHANICAL THEORY: Schrödinger formalism and density matrix formalism for calculating the nonlinear susceptibility tensor, interpretation of expressions for 1st, 2nd and 3rd order susceptibilities.

4. WAVE EQUATION FOR NONLINEAR OPTICAL INTERACTIONS: The wave equation applied to sum-frequency and difference-frequency generation, phase matching and energy relations.

5. APPICATIONS OF NONLINEAR OPTICS IN RECENT RESEARCH PROJECTS: Examples that are discussed are closely related to research projects in the department. It includes frequency doubling in crystals, four-photon sum- frequency generation of tunable vacuum ultraviolet light and surface second harmonic generation with femtosecond pulses.

6. OPTICAL MODULATION: Electro-optical modulation (Kerr and Pockels effects), magneto-optical modulation (Faraday effect) and acousto-optical modulation (Bragg and Raman-Nath scattering).

Formal lectures

Practical (Tutorials):

Students are expected to complete tutorial problems and assignments.

Study material:

Prescribed textbook: Nonlinear Optics, RW Boyd, Academic Press, London, 1992.
The textbook is available as e-book through the SU library at this link:
http://www.sciencedirect.com.ez.sun.ac.za/science/book/9780123694706
Additional study material will be provided.

Learning opportunities:

Class discussions and tutorial problems.
It will be announced closer to the start of the module how the lectures and tutorials will be conducted in the context of augmented learning.

Assessment:

Methods of Assessments
Tutorial problems, assignments and tests contribute to the continuous assessment.
Tests will be scheduled by the Physics Department and will be sit-down tests.