Fundamentals of Nonlinear Optics
Course Outline

Instructor: Dr. Sergey Ponomarenko (office: Sexton Campus C313; phone: 494-3270; email: serpo@dal.ca).

Objectives. The purpose of this course is to expose engineering and physics students to fundamental concepts of nonlinear optics.

Syllabus

- Propagation of plane electromagnetic waves in free space.
- Light propagation in conductors.
- Light propagation in linear anisotropic media: Faraday effect, uniaxial crystals.
- Refraction of plane waves at the interface of two dielectric media. Fresnel formulas.
- Multi-beam interference, Fabry-Perot etalon; light propagation in linear layered media.
- Surface electromagnetic waves. Surface plasmon polaritons in metals.
- Diffraction of light in free space. Gaussian beam optics.
- Lorentz (oscillator) model for linear optical susceptibility.
- Theory of linear dispersion and absorption.
- Optical pulses; group velocity and group velocity dispersion.
- Near-resonant propagation of optical pulses in linear media.
- Introduction to nonlinear optics: Qualitative description of basic nonlinear optical interactions.
- Formal definition and properties of linear and nonlinear optical susceptibilities.
- Causality and Kramers-Kronig relations.
- Coupled-wave equations for nonlinear optical interactions.
- Second-harmonic generation.
- Manley-Rowe relations. Phase-matching considerations.
- Sum- and difference- frequency generation (parametric up- and down-conversion).
- Third-harmonic generation.
- Self-focusing of light and spatial soliton formation.
- Z-scan and measurement of the third-order nonlinear coefficient.
- Nonlinear polarization effects in isotropic media
- Quadratic electro-optical effect.
- Stimulated Raman scattering.

General Literature

- E. G. Sauter, *Nonlinear Optics*, (Wiley, New York, 1996).
- R. W. Boyd, *Nonlinear Optics*, (Academic Press, Boston, Amsterdam, 2003), 2nd ed.
- J. D. Jackson, *Classical Electrodynamics,* (Wiley, 1999), 3rd ed.

More elementary textbooks

- M. N. O. Sadiku, *Elements of Electromagnetics*, (Oxford University Press, 2010), 5th ed.
- G. R. Fowles, *Modern Optics*, (Dover Publications, 1975).

Resonant light-matter interactions

- L. Allen and J. H. Eberly, *Optical Resonance and Two-level Atoms,* (Dover, 1987), Chap. 1.
- P .W. Milonni and J. H. Eberly, *Lasers*, (Wiley 1988), Chaps. 2 & 3.

Paslmonics

- S. A. Maier, *Plasmonics: Fundamentals and Applications*, (Springer, 2007).

Fiber Optics

- G. P. Agrawal *Nonlinear Fiber Optics*, (Academic Press, 2007), 4th ed., Chaps. 1 through 4.

Method of Instruction

- Weekly Lectures TBA (Room C365, Sexton Campus).

Method of Evaluation

- There will be **three** homework assignments throughout the course, each will be due by a particular date. Your grade for the course will be an average of the grades you obtain for each assignment.

Prerequisites

- Engineering students: ECED 3300 (Electromagnetic Fields), ECED 4500 (Electromagnetic Waves and Propagation), ENGM 2062 (Engineering Mathematics IV), or permission of the instructor.
- Physics students: PHYC 5100 (Electromagnetism) and PHYC 5160 (Mathematical Methods in Physics), or permission of the instructor.