Syllabus - PH683 Nonlinear Optics

Concepts

Nonlinear optical phenomena comprise the basis for many important technologies and research tools. This course develops the underlying concepts from the perspectives of classical electrodynamics and advanced quantum mechanics.

Student Learning Outcomes

- Understand sources of and propagation of optical electromagnetic waves.
- Simulate and measure experimentally commonly used nonlinear optical phenomena commonly used in industry.
- Understand nonlinear phenomena from the fundamental perspective of quantum mechanics.
- Communicate basic concepts and applications effectively.
- Gain the ability to perform research and development projects using advanced theoretical and experimental skills and tools.

Learning Resources

- Required books: *Nonlinear Optics, 3rd Ed.* by Robert Boyd
- Recommended books: *Principles of Nonlinear Optics, 2nd Ed.* by Y. R. Shen.
- Lecure notes and references to journal articles are available on the course website.

Meeting Times

- Lectures: Monday, Wednesday and Friday 14:00 to 15:30 in 304 Weniger

Instructor

- William M. Hetherington, Associate Professor of Physics
  105 Weniger Hall, 541-737-1689, hetheriw@physics.oregonstate.edu

Evaluation of Student Performance

- Problem sets on individual topics 75%
- Group project involving multiple concepts and analyses of published research 25%

Topics

Classical Electrodynamics and Nonlinear Optical Phenomena

- Review of wave propagation and linear response theory.
- Nonlinear response theory and nonlinear source terms in coupled wave equations.

Quantum Mechanical Foundations of Nonlinear Optical Phenomena

- Description of the radiation field in terms of number and coherent states.
- Hamiltonian with matter, field and interaction terms.
- Time evolution operator and iterative solution to the Schroedinger equation.
- Development of nth order nonlinear behavior.

Incoherent NLO Phenomena

- Two-photon absorption and Raman scattering.
- Multi-photon processes

Coherent NLO Phenomena

- Stimulated Raman gain.
- Three-wave mixing: second harmonic generation, parametric mixing
- Four-wave mixing: third harmonic generation, degenerate four-wave mixing, CARS.
- Nonlinear index of refraction, self-focusing, self-phase modulation and short pulse generation.

Applications

- Femtosecond lasers
- Spectroscopic techniques