PHY 355 Lasers and Nonlinear Optics

Syllabus Spring 2009

Ivan Biaggio
407 Lewis Lab
(610) 758-4916
biaggio@lehigh.edu
http://www.lehigh.edu/~ivb2/

Class Schedule:

Tuesdays and Thursdays from 10:45 am to 12:00 pm.

Course description:

This course is designed for advanced undergraduate and graduate students having some previous exposure to the field of optics, and wishing to become knowledgeable in the basic principles that govern the operation of lasers and the light-matter interaction effects collectively known as nonlinear optics.

For ***lasers***, we will discuss the basic principles that allow for laser operation (namely stimulated emission, population inversion, and resonators), coherence of laser light, Gaussian beams, Laser resonators, Q-switching, mode-locking, and rapidly review the most common laser systems used in science and technology.

In ***nonlinear optics***, we will study the origin, symmetry, and definitions of the nonlinear optical susceptibilities that describe multi-photon interactions mediated by matter. The basic emphasis will be on the presentation and discussion of the analysis tools that allow the description and understanding of nonlinear optical effects. A list of topics: Measurement of nonlinear optical properties and discussion of the pitfalls arising from the inconsistent definitions found in the literature; Molecular hyperpolarizabilities and macroscopic nonlinearities; Second and third order effects; Wave interaction in anisotropic crystals; Phase matching; Frequency conversion (*e.g.* frequency doubling and tripling); Optical Kerr effect; All optical switching; Four-wave mixing.

We will touch several current topics of interest related to the material in the course. In fundamental research, lasers and nonlinear optical techniques can deliver information on the symmetry of materials and interfaces, on the excited states of matter, and on the workings of a multitude of material excitations. In technology, nonlinear optical effects are used to change the color of laser beams, to create short laser pulses, to build “optical transistors”, and are critical for the understanding and optimization of information-transmission in optical fibers and elsewhere.

What you will learn:

After this course you will be able to understand, operate, and use many different kinds of laser systems, and also to design and build a simple one. Moreover, you will be able to understand and analyze the nonlinear optical effects that laser beams induce in transparent materials and that are of the second order and of the third order in the optical electric field. If faced with a new phenomenon or effect, you will be able to analyze it with the tools presented in this course and understand its origins and implications.

Required coursework and grading distribution:

30%: Short Quizzes
20% Homeworks
50% Exams

Quizzes are simple, 5-minute questions that you will answer in writing in class, from time to time. Quizzes will be graded from 0 (if you are not there or do not write anything) to 3 (if everything is perfect). Only the top 70% will contribute to the final grades.

Homeworks are due every week and complement the material in the lecture. I will give 1 point for an attempt to solve a problem, 2 points for a more complete discussion of the solution, 3 points for very good solutions, and 0 points if you don't do anything. Solutions will be discussed in class after the problems have been turned in and after you have had the time to study the solutions I wrote. As a result, I cannot accept late homeworks. Hand in whatever you have done! *Homework problems are a very important part of the course and it is important that you seriously attempt to understand them and to solve them as soon as you get them*. Homeworks are designed to lead you towards a better understanding of the material of the course. They are qualitatively different from exam questions and quiz questions, but understanding homeworks will give you the tools and the abilities to easily answer quiz questions and exam questions. It is the same as athletics, without exercise you cannot be good. Important: try to make an attempt to solve the homeworks *alone*. It is tempting to do it by committee all together from the start, but this more or less destructs the purpose of the homework, and it is especially unhelpful for the weaker students. Come to me if you have questions.

Exams. There will be a mid-term exam and a comprehensive final exam. The mid-term exam is only counted for the final grade if its grade was better than the grade in the final exam. If both exams are counted, the total grade will be given by $(m + 2f)/3$, where m is the grade of the mid-term, and f the grade of the final. Exam questions are designed to test your knowledge in the field while requiring only little mathematical calculations. They are a bit longer than quiz questions, but are more similar to the quizzes than to the homeworks. Exams will provide a large number of questions and you will not need to solve all of them to obtain the maximum grade.

Accommodations for Students with Disabilities: If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.