PHYS 953 – Adv. Topics/Non-linear and Quantum Optics - Fall 2010

Lecture: T/U, 1:05-2:20 p.m. CW 145

Textbooks: *Nonlinear Optics,* Boyd; *Introductory Quantum Optics*, Gerry and Knight;

Suggested References: *Introduction to Quantum Optics, From Light Quanta to Quantum Teleportation*, Paul; *The Quantum Challenge*, Greenstein and Zajonc; *Quantum Optics*, Walls and Milburn; *Coherence and Quantum Optics*, Mandel and Wolf; *Nonlinear Optics*, Shen; *Nonlinear Fiber Optics*, Agrawal; *Handbook of Nonlinear Optics*, Sutherland; *Handbook of Nonlinear Optical Crystals,* Dmitriev, Gurzadyan, and Nikogosyan; *Electromagnetic Noise and Quantum Optical Measurements*, Haus;

Instructor: Dr. Brian R. Washburn, CW 36B, (785) 532-2263, washburn@phys.ksu.edu. Office hours: M/W/F 9:30-10:30 PM or by appt.

Prerequisites: A solid foundation in undergraduate-level quantum mechanics, electromagnetism, and optics.

Course Objective: The purpose of this course is to provide an introduction to the field of nonlinear optics, exploring the physical mechanisms, applications, and experimental techniques. Furthermore the fundamentals of quantum optics will be taught in the second half in this course. Connections between quantum and nonlinear optics will be highlighted throughout the semester. My goal is for students to end up with a working knowledge of nonlinear optics and a conceptual understanding of the foundations of quantum optics.

Grading:

Exam 1	150 pts	300 pts
Exam 2	150 pts	
Mini-Projects		500 pts
Final Project		200 pts
Total possible		**1000 pts**

Exams: There will be two exams during the semester. The format will be a take-home exam to be completed over 24 hours.

Mini-Projects: Problems in nonlinear and quantum optics are quite involved, so traditional homework assignments will not properly teach the material. So, the homework for this course will be in the form of mini-projects. The mini-projects will be a detailed solution of interconnected problems related to lecture topics. The problems will need to be solved using resources beyond the textbook and class notes. The purpose of the mini-projects is to mimic problem-solving scenarios found in a research environment.

There will be between 5-7 mini-projects, each given with two or more weeks for completion. Working on the mini-projects in groups is strongly encouraged, but you will need to write up the assignment on your own.

Final Project: There will be a final project for the class but no final exam. The final project will be an investigation of a topic or problem in the areas of nonlinear and quantum optics, that will involve a literature search and some original work. The final project will consist of three parts:

Part 1: Abstract and bibliography
Part 2: 6 page paper plus references
Part 3: 15 minute presentation

Late Projects: No project will be accepted after its due date unless prior arrangements have been made. Please inform me with possible conflicts before the due date, and other arrangements will be made.

Class Material: Extra class materials are posted on K-state Online, including papers and tutorials.

Disabilities: If you have any condition such as a physical or learning disability, which will make it difficult for you to carry out the work as I have outlined it or which will require academic accommodations, please notify me and contact the Disabled Students Office (Holton 202), in the first two weeks of the course.

Plagiarism: Plagiarism and cheating are serious offenses and may be punished by failure on the exam, paper or project; failure in the course; and/or expulsion from the University. For more information refer to the "Academic Dishonesty" policy in K-State Undergraduate Catalog and the Undergraduate Honor System Policy on the Provost's web page: http://www.ksu.edu/honor/.

Tentative Course Schedule, Nonlinear and Quantum Optics, PHYS 953, Fall 2010

Date	Topic	Chapters	Projects
Aug. 24 (T)	Class overview: review of linear optics and the semi-classical treatment of light Review of material dispersion and absorption		
Aug. 26 (U)	Introduction to nonlinear optics: the nonlinear susceptibility —Formal definitions —Nonlinear optics and mechanics: analogy to anharmonic motion	B1	
Aug. 31 (T)	The Maxwell's wave equation in a nonlinear medium Symmetry and nonlinear optical properties	B1	
Sept. 1 (U)	Second order nonlinear effects —Coupled equations: Sum frequency and second harmonic generation —Phase matching in second harmonic crystals	B2	MP1 Due
Sept. 7 (T)	Second harmonic generation with ultrashort pulses —Phasematching and bandwidth issues	B2	
Sept. 9 (U)	Difference and sum frequency generation —Parametric amplification in crystals, optical parametric oscillators	B2	
Sept. 14 (T)	No Class (need to make this day up)		
Sept. 16 (U)	No Class (need to make this day up)		
Sept. 21 (T)	Applications for second harmonic generation —Ultrashort pulse measurements	B2	
Sept. 23 (U)	Applications for second harmonic generation —Carrier-envelope phase measurement: the *f*-to-2*f* interferometer		MP2 Due
Sept. 28 (T)	Catch up day!		
Sept. 30 (U)	Third order nonlinear effects: Intensity dependent refractive index; four-wave mixing Nonlinear fiber optics: fiber parametric oscillators	B4, B13	
Oct. 5 (T)	More nonlinear fiber optics —Pulse propagation in a third order nonlinear medium, soliton generation	B4, B13 Exam 1	
Oct 6 (W)	Exam 1 Due		
Oct. 7 (U)	Spontaneous and stimulated Raman scattering —Spontaneous Raman scattering —Stimulated Raman scattering in third order media	B4	
Oct. 12 (T)	More on stimulated Raman scattering: CARS spectroscopy	B9	
Oct. 14 (U)	Third order effects in gases: applications for short pulse generation	B9	MP3 Due
Oct. 19 (T)	High field processes: higher harmonic generation	B13	
Oct. 21 (U)	Introduction to quantum optics: What is a photon? —The photoelectric effect —The Hanbury-Brown and Twiss experiment	G1	
Oct. 26 (T)	No Class (need to make this day up)		
Oct. 28 (U)	What is a photon? —The photoelectric effect revisited: Lamb and Scully —The Aspect experiments	G1	
Nov. 2 (T)	What is a photon? —Wheeler's delayed choice experiment —Quantum beat experiments	G2	
Nov. 4 (U)	Field quantization and coherent states	G2	
Nov. 9 (T)	More on coherent states	G2,G3	MP4 Due
Nov. 11 (U)	Interferometry with a single photon	G2,G3	
Nov. 16 (T)	Bell's theorem and quantum entanglement —EPR Paradox and Bell's Theorem	G9 Exam 2	
Nov. 17 (W)	Exam 2 Due	Final project part 1 due	
Nov. 18 (U)	Optical tests of EPR: violations of the Bell's inequality	G9	
Nov. 23 (T)	Thanksgiving Break		
Nov. 25 (U)	Thanksgiving Break		
Nov. 30 (T)	Nonclassical light: squeezed states	G9	
Dec. 2 (U)	Optical tests of quantum mechanics	G9	MP5 Due
Dec. 7 (T)	Catch up day!	Final project part 2 due	
Dec. 9 (U)	Final Project Presentations	Final project part 3 due	
Dec. 14 (T)	Final Project Presentations: Exam Period 2:00 PM – 3:50 PM		

Books: B= Boyd, *Nonlinear Optics*, G= Gerry and Knight, *Introductory Quantum Optics*;