PHYS 953 – Adv. Topics/Non-linear and Quantum Optics - Fall 2007
Lecture: M/W/F, 12:30-1:30 a.m. Willard 25

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. Sorry! Please inform me with possible conflicts before the due date, and other arrangements will be made (if you ask really nicely).

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 2007

Date	Topic	Chapters	Projects
Aug. 20 (M)	Introduction to nonlinear optics —Class overview, review of linear optics and the semi-classical treatment of light	B1	
Aug. 22 (W)	—Review of material dispersion: stuff you should know already	B1	
Aug. 24 (F)	—The nonlinear susceptibility: formal definitions	B1	
Aug. 27 (M)	—The nonlinear susceptibility: analogy to anharmonic motion	B1	
Aug. 29 (W)	—The nonlinear susceptibility: properties of materials	B1	
Aug. 31 (F)	—Symmetry and nonlinear optical properties	B1	
Sept. 3 (M)	No Class		
Sept. 5 (W)	—The Maxwell's wave equation in a nonlinear medium		
Sept. 7 (F)	Second order nonlinear effects —Second harmonic generation	B2	MP1 Due
Sept. 10 (M)	—Phase matching in second harmonic crystals	B2	
Sept 12 (W)	—Second harmonic generation with ultrashort pulses	B2	
Sept. 14 (F)	—Difference and sum frequency generation	B2	
Sept. 17 (M)	—Parametric amplification in crystals, optical parametric oscillators*	B2	
Sept. 19 (W)	—Quasi-phasematching in periodically poled materials	B2	
Sept. 21 (F)	Applications for second harmonic generation —Ultrashort pulse measurement: intensity and interferometric autocorrelators		
Sept. 24 (M)	—Ultrashort pulse measurement: FROGs, SPIDERs, and TADPOLEs		
Sept. 26 (W)	Carrier-envelope phase measurement: the *f*-to-2*f* interferometer		
Sept. 28 (F)	Third order nonlinear effects —Intensity dependent refractive index; four-wave mixing	B4	MP2 Due
Oct. 1 (M)	No Class		
Oct. 3 (W)	—Pulse propagation in a third order nonlinear medium: nonlinear fiber optics	Exam 1	
Oct 4 (U)	Exam 1 Due		
Oct. 5 (F)	—Nonlinear fiber optics: solitons and similaritons	B4, B13	
Oct. 8 (M)	—Spatial third order effects: self focusing and light bullets*	B4, B13	
Oct. 10 (W)	Applications of third order effects and high-intensity lasers —Short pulse generation using nonlinear effects	B13	
Oct. 12 (F)	—Nonlinear pulse compression in gases	B13	MP3 Due
Oct. 15 (M)	Spontaneous and stimulated Raman scattering* —Spontaneous Raman scattering	B9	
Oct. 17 (W)	—Stimulated Raman scattering in third order media, CARS spectroscopy*	B9	
Oct. 19 (F)	Introduction to quantum optics —What is a photon? The Hanbury-Brown and Twiss experiment	G1	
Oct. 22 (M)	—What is a photon? The Aspect experiments	G1	
Oct. 24 (W)	Field quantization and coherent states —Quantization of a single mode field	G2	
Oct. 26 (F)	—Vacuum fluctuations and the zero-point energy	G2	MP4 Due
Oct. 29 (M)	—The quantum phase	G3	
Oct. 31 (W)	—Coherent states: light waves as harmonic oscillators	G3	
Nov. 2 (F)	—Properties of coherent states, phase-space pictures	G3	
Nov. 5 (M)	—Review of the density operator, phase-space probability functions	G3	
Nov. 7 (W)	Emission and absorption of radiation by atoms —Atom-field interactions: classical and quantized fields	G4, B6	
Nov. 9 (F)	—Optical Bloch equations, the Rabi model	G4, B6	MP6 Due
Nov. 12 (M)	—Ramsey fringes, the Jaynes-Cumming model*	Exam 2	
Nov. 13 (T)	Exam 2 Due	Final Project Part 1Due	
Nov. 14 (W)	Nonclassical light* —Squeezed states, applications of squeezing in gravity wave detection	G7	
Nov. 16 (F)	—Squeezing and nonlinear fiber optics		
Nov. 19 (M)	Bell's theorem and quantum entanglement —EPR Paradox and Bell's Theorem	G9	
Nov. 21 (W)	No Class		
Nov. 23 (F)	No Class		
Nov. 26 (M)	—Bell's Theorem and the Aspect experiment	G9	MP5 Due
Nov. 28 (W)	—Violation of Bell's theorem using an optical parametric amplifier	G9	
Nov. 30 (F)	Optical tests of quantum mechanics —The Hong-Ou-Mandel interferometers	G9	
Dec. 3 (M)	—Quantum beats, quantum demolition measurements	Final Project Part 2 Due	
Dec. 5 (W)	—The Franson experiment	G9	
Dec 7 (F)	Final Project Presentation	Final Project Part 3 Due	
Dec 10 (M)	Final Project Presentation, final exam period 4:10 p.m. - 6:00 p.m.	Final Project Part 3 Due	

Books: B= Boyd, *Nonlinear Optics*, G= Gerry and Knight, *Introductory Quantum Optics*; * denotes a topic that may be replaced with something much more interesting

BRW 8/16/2007