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Hsinchu, Taiwan 300 *IPT5110 Spring, 2014*

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IPT5110 Nonlinear Optics

國立清華大學 光電光程研究所/電機工程學系

Prof. 黃衍介 class schedule: 9:30 am ~ 12:30 pm, Tuesday

Spring, 2014

Class location: first time meet at Delta 210 at 10:10 am Tuesday, Feb. 18, 2014.

Teaching Assistant: 吳明雄 （wuing911119@hotmail.com）, x 62333

一、課程說明

The scope of this course covers most nonlinear optical phenomena associated with the 2^{nd} and 3^{rd} order optical nonlinearities. Near the end of the semester, high harmonic generation and plasma nonlinearity in the relativistic regime will also be introduced. To assist learning, this course begins with some review on the linear electromagnetic theory and then gradually moves into the nonlinear regime. This approach is to accommodate more and more undergraduate students taking this course.

Student's participation plays a key role in this course. All students are required to give 5-6 in-class presentations to earn their grades during the whole semester.

Seeing is believing. Students are also required to carry out 3 experiments and turn in lab reports in English.

二 指定用書

1. Class handouts (available at 水木書苑 or http://www.hope.nthu.edu.tw)

三、參考書籍

0. David K. Cheng, Field and Wave Electromagnetics 2nd Ed., Addison Wesley, 1989.
1. 近代實驗光學，東華書局，黃衍介 著。
2. Nonlinear Optics by E.G. Sauter, John Wiley & Sons, 1996.
2. Fundamental of Photonics by Saleh & Teich, John Wiley & Sons, Inc.
3. Nonlinear Optics by R.W. Boyd, Academic Press.
4. Optical Waves in Crystals by Yariv and Yeh, John Wiley & Sons, Inc.
5. Quantum Electronics, by Yariv, John Wiley and Sons, Inc.

四、教學方式

Homework assignment

A student is required to turn in a set of presentation slides each week as a weekly homework assignment. The total number of slides is between 25 and 30, approximately 1 slide for 1 page of the course reader. Each student has to bring a memory stick to the class and get ready for a presentation. Before the class, all students have to email their slides in the pdf format to the teaching assistant and Prof. Huang. The file size can't exceed 1 Mb.

Presentation

In each class, I **randomly** select 3-4 students, each giving half an hour presentation and host a Q&A session by using approximately 5-10 slides (including 1 slide of 3 questions). A presenter's performance will be graded by both the professor and the fellow students in the audience. Each student is expected to give 5-6 presentations in a semester.

Laboratories

During the semester, students are required to carrying out 3 experiments on the 2nd floor of the HOPE Laboratory. Each student is asked to turn in a laboratory report, due in 10 days from the first day you work on the experiment. Detailed description for the laboratory sessions is given below.

Exams

Exams are all open book/note ~~and only provide tests of basic concepts~~.

五、教學進度

1. Electromagnetic waves in the linear regime (D. K. Cheng, Huang)
2. Electromagnetic Wave in Anisotropic Media (Ch. 2 by Sauter, Ch. 6 by S&T, Ch. 4 by Y&Y)
3. Nonlinear Susceptibility (Ch. 1 by Boyd, Ch. 1 by Sauter)
4. Electro-optics (Ch. 3 by Sauter, Ch. 18 by S&T, Ch. 7 by Y&Y, Ch. 10 by Boyd)
5. Acousto-optics (Ch. 20 by S&T, Ch. 9 by Y&Y, Ch. 7 by Boyd)
6. Second harmonic generation (Ch. 2, 4 by Sauter, Ch. 19 by S&T)
7. Other Frequency Conversions using 2nd-order Nonlinearity (Ch. 4&5 by Sauter, Ch. 2 by Boyd, Ch. 19 by S&T, Ch. 12 by Y&Y)
8. Quasi-phase-matching nonlinear optics (handout)
9. Third-order Nonlinear Processes: third-harmonic generation, conjugate waves, Brillouin scattering, and Raman Scattering (Ch. 6 by Sauter, Ch. 18 by Yariv, Ch. 19 by S&T)
10. DC and AC Kerr Effect (Ch. 7 by Sauter, Ch. 19 by S&T)

11. High harmonic generation and plasma nonlinear optics

Week 1 (Feb. 18th, Feb. 21) : up to page 30 of the course reader
Week 2 (Feb. 25th): up to page 60
Week 3 (March 4th): up to page 90
Week 4 (March 11th): up to page 115
Week 5 (March 18th) – Midterm exam 1
Week 6 (March 25th): up to page 140
Week 7 (April 1st): up to page 165 (electro-optic experiment)
Week 8 (April 8th): up to page 190
Week 9 (April 15): up to page 215
Week 10 (April 22nd) – Midterm exam 2
Week 11 (April 29th): up to page 240 (Non-critically Phase-matched SHG)
Week 12 (May 6th): up to page 265
Week 13 (May 13th): up to page 290
Week 14 (May 20th): up to page 318 (Optical Parametric Generation)
Week 15 (May 27th): up to page 351
Week 16 (June 3rd): up to page 380
Week 17 (June 10th) – Final Exam

六 、成績考核

Homework	20%
presentation	25% (15% graded by peers)
laboratory report (due 1 week after experiment)	25%
1st midterm exam	10%
2nd midterm exam	10%
Final exam	10%

Q&A – reference for score adjustment (Prof. Huang will keep a record of questions asked by you during and off the class)

七、講義位址 chapter files available at http://www.hope.nthu.edu.tw (passcode to access: 20145110) and bound copies available at 水木書苑 on Feb. 21st.

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Presentation Grading Sheet/YC Huang

Grader's name: _____ Grader's ID #: _____

Date (mm/dd/yyyy): _____

1st presenter's name:

A+ (90-100)	A (85-89)	A- (80-84)	B+ (77-79)	B (73-76)	B- (70-72)	C (60-69)	D (1-59)	X (0)

2nd presenter's name:

A+ (90-100)	A (85-89)	A- (80-84)	B+ (77-79)	B (73-76)	B- (70-72)	C (60-69)	D (1-59)	X (0)

3rd presenter's name:

A+ (90-100)	A (85-89)	A- (80-84)	B+ (77-79)	B (73-76)	B- (70-72)	C (60-69)	D (1-59)	X (0)

4th presenter's name:

A+ (90-100)	A (85-89)	A- (80-84)	B+ (77-79)	B (73-76)	B- (70-72)	C (60-69)	D (1-59)	X (0)

5th presenter's name:

A+ (90-100)	A (85-89)	A- (80-84)	B+ (77-79)	B (73-76)	B- (70-72)	C (60-69)	D (1-59)	X (0)

IPT5110L Nonlinear Optics Lab

Location: 2nd-floor 高能光電實驗室 teaching laboratory

Experiment 1 Electro-optic Modulation (TA: 黃冠諺、王博誠)

Measurement: Measure the half-wave voltage of an electrode-coated lithium niobate
Instruments & Components: HeNe laser or a frequency-doubled Nd laser, function generator, voltage amplifier (transformer) with DC voltage offset, polarizer, silicon detector

Experiment 2 Non-critically phase-matched Second harmonic generation in lithium niobate （TA: 吳明雄、許應捷）

Measurement: Identify the crystal axis, Sinc curve (temperature bandwidth for various crystal lengths), conversion efficiency (nonlinear coefficient), angular bandwidth
Instruments & Components: Diffuser, HeNe laser, 1064 nm PQS laser, prism or filter, oven+controller, crystals, silicon detector, oscilloscope, printer, rotation stage

Experiment 3 Optical Parametric Generation (OPG) （TA: 邱鈺中、蘇正國）

Measurement: Measure the wavelength tuning curves as a function of the temperature, output signal + idler power vs. pump power, OPG spectral width vs pump energy.
Instruments & Components: 1064-nm PQS laser, monochrometer, oven+controller, crystals, silicon detector, oscilloscope, waveplate etc.

Arrangement of the Lab Experiment

1. Each lab group consists of 3-4 students at most, supervised by 1-2 TAs from Huang's group.
2. Each group takes one day from the 5 week days for doing the

experiments. For example, Group 1 takes each Monday for doing the experiments.

3. If failure of any instrument and component is due to **carelessness or lack of common sense** in experiments, 5% of the final grade is deducted from the very student who causes the failure and 2% of the final grade is deducted from each of the other group members.
4. All the experiments have to be completed in one week for each assignment. The lab report has to be turned in 10 days from the day you do the experiment.

Requirements on Lab Reports

1. The report has to be written in **good** English.
   The lab report has to include the following sections
   i. Purpose of the experiment
   ii. Principle of the experiment
   iii. Comparison between experimental data with theoretical curves/prediction. (offer reasonable explanations to any discrepancy)
   iv. Conclusions of the experiment

2. All laboratory reports have to be written in the two-column format of *Optics Letters*. See http://www.osa.org for the official format. Usually there are 4 graphs in each letter paper. A letter paper is limited to 4 pages.
3. The grating policy is as follows
   a. Format 20%
   b. English 40%
   c. Content 40%
4. Past-deadline reports are not accepted. Please observe the deadline for each report.
5. Email an electronic copy of your report to Prof. Huang at ychuang@ee.nthu.edu.tw by the deadline. Use name_ID_#ofexperiment.doc as your file name. The file size can't exceed 1 Mb.