Prof. Yen-Chieh Huang *ext. 62340*
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Hsinchu, Taiwan 300 *IPT54100 Spring, 2017*

Last update Jan. 22, 2017

IPT54100 Laser and Nonlinear Optics Laboratory

雷射與非線性光學實驗

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: R5R6R7R8

Spring, 2017

Class location: 光電中心高能光電實驗室

Teaching Assistant: TBA x 62333

一、課程說明

This course is to help students develop laboratory skills on modern photonics, including laser and nonlinear optics. The course first teaches a student the operation of basic instruments, such as oscilloscope, photodetector, lockin amplifier, monochromator, and spectrophotometer etc. The students then get hand-on experience on characterizing laser beam, laser mode, laser gain, and laser Q-switching. The third part of the laboratory course is about electro-optic modulation and laser wavelength conversion utilizing the 2^{nd} and 3^{rd} order optical nonlinearity in materials. The lectures of this course are merged with the course "IPT 51100 Nonlinear Optics"

二 指定用書

1. Laboratory 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. Optical Waves in Crystals by Yariv and Yeh, John Wiley & Sons, Inc.
4. Quantum Electronics, by Yariv, John Wiley and Sons, Inc.

四、教學方式

- **Lectures: merged with** "IPT 5110 Nonlinear Optics" at 台達 Delta 202
- **Laboratories**

During the semester, students are required to carrying out 10 experiments on the 2nd floor of the HOPE Laboratory. Each student is asked to turn in a laboratory report, due in 7 days from the first day you work on the experiment. Detailed description for the laboratory sessions is given below.

- **Exams**

Merged with. "IPT 51100 Nonlinear Optics"

五、教學進度

Week 0, First meeting

Lecture: Electromagnetic Wave

Lecture: Gaussian Laser Beam

Week 1, Feb. 20th

- Experiment 1 photonics measurement – photodetector, pulse, wavelength, absorption, noise

Lecture: Optical Resonator

Lecture: Wave Propagation in Aniosropic Material

Week 4, March 13th

- Experiment 2 Laser transverse modes: Transverse modes generation from externally injected HeNe laser cavity. Gaussian Beam Characterization – M^2 measurement

Lecture: Acousto-optics

Week 6, March 27th

- Experiment 3 AO modulation

Lecture: Laser

Week 8 April 10th

- Experiment 4 diode pumped Nd:YAG laser: relaxation oscillation, upper state lifetime, Q-switching, longitudinal mode etc.

Lecture: Nonlinear susceptibility

Lecture: Electro-optics

Week 10, April 24th

- **Experiment 5: Electro-optic Modulation (TA: TBA)**

1. Measurement: Measure the half-wave voltage of an electrode-coated lithium niobate and observe 1-f & 2-f modulation
2. Instruments & Components: HeNe laser or a frequency-doubled Nd laser, function generator, voltage amplifier (transformer) with DC voltage offset, polarizer, silicon detector

Lecture: $\chi^{(2)}$ optical frequency up-conversion

Week 12, May 8th

- **Experiment 6 Non-critically phase-matched Second harmonic generation in lithium niobate （TA: TBA）**

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

Lecture: $\chi^{(2)}$ optical frequency down-conversion

Week 14, May 22nd

- **Experiment 3 Optical Parametric Generation (OPG) （TA: TBA）**

1. 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.
2. Instruments & Components: 1064-nm passively Q-switched laser, monochrometer, oven+controller, crystals, silicon detector, oscilloscope, waveplate etc.

Lecture: Third-order Nonlinear Frequency Mixing

Week 16 June 5th

- **Experiment 8 Stimulated Raman Scattering (SRS) （TA: TBA）**

1. Measurement: Measure the Stokes shift of a silica fiber, determine the Raman gain, and observe multiple Stokes generation.
2. Instruments & Components: 1064-nm passively Q-switched laser, monochrometer, optical fiber, silicon detector etc.

六 、成績考核

Homework (TRY to answer all the questions in the lab handout prior to a lab)	20%
Laboratory report (due 7 days after a lab)	50%
Midterm exam (joint with IPT51100)	15%
Final exam (joint with IPT51100)	15%

Q&A – reference for score adjustment (Prof. Huang will keep a record on your asking questions during and off the class)

七、講義位址 available at http://www.hope.nthu.edu.tw (passcode to access: TBA) and bound copies available at 水木書苑 by March 2nd

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Arrangement of the Lab Experiment

1. Each lab group consists of <3 students at most, supervised by 1-2 TAs from Huang's group.
2. Each group takes one day from the 5 weekdays 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 **apparent 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 7 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/4 figures.
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 in the WORD format 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.

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IPT54100 Laser and Nonlinear Optics Lab Group Signup Sheet

Spring, 2017

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

Monday	Tuesday	Wednesday	Thursday	Friday
Name, ID, phone #	Name, ID, phone #	Name, ID, phone #	Name, ID, phone #	Name, ID, phone #