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Hsinchu, Taiwan 300 *IPT54100 Spring, 2018*

Last update Feb. 25th, 2018

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
Institute of Photonics Technologies, National Tsinghua University, Hsinchu 30013, Taiwan

Prof. 黃衍介

Spring, 2018b

- The first meeting is at M5, Feb. 26th, 2018, at Delta 209
- For the laboratory sessions, the classroom is located at 光電中心高能光電實驗室, HOPE Laboratory

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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 2nd and 3rd order optical nonlinearity in materials. Most of the lectures of this course are merged with the course "IPT 51100 Nonlinear Optics"

二 指定用書

1. Laboratory handouts (available at the on-campus 利捷影印店 or 水木書苑 or http://www.hope.nthu.edu.tw during the week of Feb. 26)

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 209
- **Laboratories**

During the semester, students are required to carrying out 8 experiments on the 2nd floor of the HOPE Laboratory (高能光電實驗室), one experiment every other week. Each student is asked to turn in a laboratory report, due in 7 days from the first day working on the experiment. Detailed description for the laboratory sessions is given below.

- **Exams**

Merged with. "IPT 51100 Nonlinear Optics"

- Homework

  Before each laboratory session, email Prof. Huang and the teaching assistants a pre-report containing at least 10 answers or speculated answers to those questions in the laboratory reader. If you can't find questions in the lab reader, please design the questions by yourself.

五、教學進度

* The persons listed after an experiment are responsible for collecting the components and set up the experiment before the first day of the laboratory session.

Week 0, Feb. 26th, First meeting

Reading Material: Electromagnetic Wave

Reading Material: Gaussian Laser Beam

Week 1, March 5th

- **Experiment 1 Photonics measurement** (蘇士祺、吳冠佑) – photonics instruments, photodetector, pulse, wavelength, absorption, noise

Reading Material: Optical Resonator

Reading Material: Wave Propagation in Aniostropic Material

Week 4, March 19th

- **Experiment 2 Laser transverse modes** (麥家銘、劉子祺): Transverse modes generation from externally injected HeNe laser cavity. Gaussian Beam Characterization – M^2 measurement

Reading Material: Acousto-optics

Week 6, April 2nd

- **Experiment 3 Acousto-optic modulation** (蔡瑋哲、陳鈺琅)

Reading Material: Laser

Week 8 April 16th

- **Experiment 4 diode pumped Nd:YAG/Nd:YVO_4 laser**: relaxation oscillation, upper state lifetime, Q-switching, longitudinal mode etc. (蔣弘儒、郭育豪)

Reading Material: Nonlinear susceptibility

Reading Material: Electro-optics

Week 10, April 30th

- **Experiment 5: Electro-optic Modulation** (蘇士祺、吳冠佑)

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

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

Week 12, May 14th

- **Experiment 6 Second harmonic generation** (麥家銘、劉子祺)

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

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

Week 14, May 28th

- **Experiment 7 Optical Parametric Generation (OPG)** (蔡瑋哲、陳鈺琅)

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.

Reading Material: Third-order Nonlinear Frequency Mixing

Week 16 June 11th

- **Experiment 8 Stimulated Raman Scattering (SRS)** (蔣弘儒、郭育豪)

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 and generate your questions/answers from the lab handout prior to a lab)	30%
Laboratory report (due 7 days after a lab session)	40%
Midterm exam (joint with IPT51100 Nonlinear Optics)	15%
Final exam (joint with IPT51100 Nonlinear Optics)	15%

七、講義位址 available at http://www.hope.nthu.edu.tw (passcode to access: TBA) and bound copies available at on-campus 利捷影印店 or 水木書苑 around Feb. 26th.

Arrangement of the Lab Experiment

1. Each lab group consists of 2 students at most, supervised by 1-2 TAs.
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 and Group 2 takes each Tuesday for doing the experiment.
3. All the equipment and parts are VERY EXPENSIVE. 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. If necessary, re-do the experiment to verify your argument.)

iv. Conclusions of the experiment

2. All laboratory reports have to be written in the two-column 4-page format of *Optics Letters*. See http://www.osa.org for the official format. Usually there are 4 graphs in each letter paper.
3. The grating policy is as follows
   a. Format 20%
   b. English 40%
   c. Content 40%
4. Pass-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, 2018

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 #