Phys597003  Special Topics in Physics: Ultrafast and THz Photonics

Lecture Hours: 18:20 – 21:10, Wednesday (tentative)
Location: Room Phys 313 (tentative)
Instructors: Prof. Ci-Ling Pan (潘犀靈教授)
            Room 231, Physics Building
            Tel: x42275
            E-mail: clpan@phys.nthu.edu.tw
            Office Hours: by appointment

Part of the Course will be taught by
Dr. Eric Chen (陳蔚然)
E-mail: wjchen@phys.nthu.edu.tw

Course Description:

Ultrafast Photonics, consisting of ultrafast optics and optoelectronics, have had a dramatic impact on a vast array of basic scientific and technological disciplines. An ultrafast laser is one that generates laser pulses shorter than 100 fs in duration. The theory and understanding of propagation of broad bandwidth optical signals is essential for many applications, e.g., the design of high throughput optical communications systems. Ultrafast photonics, however, also has applications ranging from studying basic processes in semiconductors and devices, watching and controlling the formation and breaking of chemical bonds, nonlinear frequency conversion for new light sources, biological and medical sensing and imaging, machining and material modification, among others. Terahertz (THz) wave, the electromagnetic radiation in a frequency interval from 0.1 to 10 THz, occupies a large portion of the electromagnetic spectrum between the infrared and microwave bands. In recent years, remarkable progress has been made in the development of Terahertz optoelectronic sources and detectors. With the development of simple solid-state femtosecond lasers and integrated optoelectronic THz-devices, a new era of fundamental and applied THz science is opening up. THz studies ranging from investigations of problems in fundamental physics, e.g., ultrafast dynamics in materials to ranging, medical and environmental imaging are actively explored. The relative new field of THz science and technology will be covered so that students can explore their applications.

Course Objective:

This course is devoted to the education of scientists and engineers who wish to use ultrafast and THz photonics as a research tool and who are not yet specialists in lasers or even optics. This course will introduce the principles of ultrafast and THz optics, including the basic theory behind generation, amplification, propagation, and manipulation of ultrafast optical and THz pulses. Current state of the art technology in these areas will be reviewed. Experimental techniques are covered. Students would be prepared for work in the modern photonics laboratories with ultrafast photonic and THz tools or to understand and evaluate the research of others working in the field of ultrafast and THz photonics. The course is appropriate for advanced seniors, masters, or Ph.D. level students, and is intended to bridge
the gap between the theoretical treatment of the wave equation from courses in Electromagnetics and the practice of ultrafast and THz photonics.

Course Contents:

- Introduction;
- Laser basics;
- Generation of Ultrashort Laser Pulses;
- Linear and Nonlinear Pulsed Optics;
- Characterization of Laser Pulses;
- Manipulation and Control of Laser Pulses;
- Ultrafast Spectroscopic Techniques;
- Ultrafast Optoelectronics;
- Terahertz Science and Technology;
- Attosecond Optics
- Selected hot topics in Ultrafast and THz Photonics.

There is no specific textbook. Please consult references below. We will heavily utilize Prof. Trebino’s course material on Ultrafast Optics, please surf and download materials from his website (see web resources below).

References:
15. Current literature

Pre-requisites:
Undergraduate electromagnetic theory; modern physics or elementary quantum mechanics; undergraduate applied or engineering mathematics. Prior exposures to optics or lasers are helpful.

Grading
Grades will be determined by incidental problem sets, a term paper with presentation, and class participation. The formula that will be used to calculate your final grade is:

Problem Sets: 40%
Term Paper: 40%
Class Participation: 20%

Resources on the Web (partial list):

1. Prof. R. Trebino’s course material on Ultrafast Optics, notes by various contributors can be found at http://frog.gatech.edu/prose.html. Slides can be downloaded at http://frog.gatech.edu/lectures.html.
Ultrashort pulses are especially important for the next generation of ultrahigh-speed optical systems and networks operating at 100 Gbps per carrier. Ultra Fast Fiber Lasers: Principles and Applications with MATLAB® Models is a self-contained reference for engineers and others in the fields of applied photonics and optical communications. Covering both fundamentals and advanced research, this book includes both theoretical and experimental results. Physics, Simulation, and Photonic Engineering of Photovoltaic Devices (Freundlich/Guillemoles). . . 237. Optical Components and Materials IX (Jiang/Digonnet/Dries). . . Â Best Student Paper Competition and Ceremony, Frontiers in Ultrafast Optics: Biomedical, Scientific and Industrial Applications XII (Conf.Â Plasmonic collimators have been successfully used to dramatically reduce beam divergence in mid-IR and THz lasers and to achieve multidirectional/multi-wavelength laser beams.Â His research has spanned a broad range of topics in the areas of solid-state electronics, photonics, QED and nanotechnology. He is a co-inventor of the quantum cascade laser.