

ASEN 5519. Fundamentals of Spectroscopy For Optical Remote Sensing

Syllabus, Fall 2013

Lecture: FLMG 103 Tuesday and Thursday at 11am–12:15pm

Instructor

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Prerequisites

The prerequisites for this class include a basic understanding of general physics and modern physics (e.g., optical and atomic physics, optical electronics, and some laser basics). These are all topics that are covered in undergraduate physics or engineering programs. If you do not have a background in one of these areas you should expect to spend some extra time on the specific material. Note – This is a graduate class and you are expected to work independently to solve problems. There are many resources, including the library, at your disposal. If you feel that you are significantly deficient in more than one of the areas listed above then you should contact the instructor.

Course Objectives

Optical (especially laser) remote sensing has become one of the most important approaches in scientific research, space exploration, environmental monitoring and protection, and industry applications, which is not only replacing conventional sensors but also creating new capabilities with unique properties that could not be achieved before. However, extensive knowledge in the atomic, molecular and laser spectroscopy is needed in order to study and further advance optical and laser remote sensing technologies. One of the goals of this spectroscopy course is to provide a comprehensive preparation for the laser remote sensing (lidar) class offered at CU. It will cover the fundamental knowledge from *quantum physics to atomic spectroscopy, and from molecular spectroscopy to laser spectroscopy*. Meanwhile, these contents are also very important parts of modern physics and technology, so they have very wide applications in many fields. Further goals of this spectroscopy course are to expose students to these modern physics and technologies, and to prepare them with the necessary knowledge and ability to pursue research and application in spectroscopy-related fields.

Objectives of the course are to:

- (1) Provide a comprehensive overview of the fundamentals of quantum physics, atomic spectroscopy, molecular spectroscopy, and laser spectroscopy.
- (2) Expose students to the spectroscopy applications in modern optical and laser remote sensing.
- (3) Help students to develop the fundamental knowledge and skills for learning new things.

The related lidar class can be found at the following website:

<http://cires.colorado.edu/science/groups/chu/classes/Spectroscopy2013/>

Course Contents

The class contains 4 major sections:

1. INTRODUCTION OF QUANTUM PHYSICS AND SPECTROSCOPY

Quantum Concepts and Experimental Facts

Wave-Particle Duality

Basics of Quantum Mechanics (Postulates, Principles, and Mathematic Formalism)

2. FUNDAMENTALS OF ATOMIC SPECTROSCOPY

Atomic Structure

Radiative Transition

Atomic Spectra

3. FUNDAMENTALS OF MOLECULAR SPECTROSCOPY

Rotational Spectroscopy

Vibrational Spectroscopy

Raman Spectroscopy

Electronic Spectroscopy

4. FUNDAMENTALS OF LASER SPECTROSCOPY

Laser Spectroscopy Basics

-- How to detect atoms and molecules?

-- How to obtain high detection sensitivity?

-- How to obtain high spectral resolution?

Doppler-limited Spectroscopy

Sub-Doppler (Doppler-free) Spectroscopy

Time-Resolved Spectroscopy

New Development

Fascinating Applications of Laser Spectroscopy

Textbooks

Textbook: Laser Spectroscopy, by Wolfgang Demtröder.

Major Reference Books for Students:

“Quantum Mechanics I, II” by Claude Cohen-Tannoudji (Nobel Laureate)

“Atomic and laser spectroscopy” by Alan Corney

“Structure and Spectra of Atoms” by Richards and Scott

“Molecular Spectroscopy” by John M. Brown

“Atomic Spectra” by T. P. Softley

Instructor’s Reference Books:

“Quantum Mechanics I, II” by Claude Cohen-Tannoudji etc

“The Principles of Quantum Mechanics” by P. A. M. Dirac

“Quantum Mechanics” by Landau and Lifshitz

“The Quantum Theory of Light” By Rodney Loudon

“Atomic and laser spectroscopy” by Alan Corney

“Quantum Theory of Atomic Structure I, II” by Slater
“Atomic Spectra and Radiative Transitions” by Sobelman
“The Theory of Atomic Spectra” By Condon and Shortley
“Molecular Spectra and Molecular Structure I, I, III” by Herzberg
“Atomic Structure and Atomic Spectra” by Lemin Zheng and Gengwu Xu
“Atomic Physics” by Lemin Zheng
“Atomic Physics” by Fujia Yang
“Laser Spectroscopy” by Lemin Zheng
“Progress in Experimental Atomic Physics” by Taiqian Dong
“Principles of Quantum Frequency Standard” by Yiqiu Wang, Qingji Wang, Taiqian Dong and Jishi Fu

The textbook was chosen for its comprehensive descriptions of quantum physics, lasers, and laser spectroscopy. There are many books on spectroscopy, laser, optics, and optical electronics. You can access them through CU Libraries.

Class Format

The class will be comprised of regular lectures two times per week. Reading and homework will be assigned. Guest lectures will be introduced to illustrate some novel applications of spectroscopy in modern optical and laser remote sensing. Laboratory trips may be arranged to see the real applications of spectroscopy in optical and laser instruments at Chu Research Group. The class will contain two take-home exams.

Course Grading

40	Homework (10 HWK)
10	Exam 1 (Introduction to Quantum Physics)
25	Exam 2 (Atomic Spectroscopy)
25	Exam 3 (Molecular and Laser Spectroscopy)
100	Total