Physics 4261: Atomic Physics

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Topic

This is an advanced undergraduate course in atomic physics intended for students with some background in quantum mechanics. Topics we will cover include the hydrogen atom (mostly as review), the helium atom, and atomic configurations and term symbols for multi-electron atoms. We will cover spectroscopy, selection rules, and some basic uses of atom-light and atom-microwave interactions such as laser cooling and atomic sensors. The goal of the course is to teach not just the basics of atomic physics, but also the ways of thinking and problem solving that atomic physicists use.

Objectives

By the end of this course, it is our goal that you will be able to:

1. Explain the origin of fine and hyperfine structure and predict their dependence on atomic number.
2. Identify the angular momentum and parity of atomic states and use this to predict which states can be mixed by interactions.
3. Given an atom's position in the periodic table, predict it's electronic configuration.
4. For a given configuration, state which terms are possible in LS and jj coupling, and which values of angular momentum can accompany them.
5. Calculate basic Clebsch-Gordon coefficients and use these to predict Zeeman shifts.
6. Use selection rules to figure out which transitions are electric dipole allowed.
7. Explain what a density matrix is and how it represents classical uncertainty
8. Write and solve the optical Bloch equations

9. Calculate Doppler shifts and explain how the Doppler effect can be used to cool atoms
10. Explain partial-wave scattering, and compare the s-wave scattering length to an effective interaction potential
11. Draw and explain the principle of the Mach-Zender interferometer for both atoms and light
12. Solve for the micromotion in an ion trap

Book

The book for the course is "Atomic Physics", by Christopher J. Foot. Some homework problems will be out of the book, some will be written by me.

Format

The course meets three times a week (MWF) for one hour at 12:05 PM. The course will consist of lectures given Wednesday and Friday. Homework will be posted weekly and due on Monday. In Monday's class, students are expected to present the solutions to their homework problems to the rest of the class, and if there is time leftover I will prepare some "bonus" material with an emphasis on applications and recent experiments. Currently I have not scheduled official "office hours", however, please send an email if you would like to meet. If needed regular office hours can be established.

Homework

Homework will be posted each week on the course website and due on Monday. Each student will be assigned a homework problem(s) throughout the semester to present in front of the class. Typing the homework using LaTeX or similar is encouraged and will receive a 5% bonus. You may work together on the homework, however everything you turn in MUST be your own writing/typing.

Exams

There will be 3 exams, including the final exam at the end of the semester. The exams will be given in class, or at the appropriate final exam time. You may use your course notes, your textbook and other printed materials, but you may NOT use internet-enabled devices or communicate with anyone else.

Final Project

At the end of the semester you will write a paper on a topic in atomic physics of your choosing (can be a chapter of the book we didn't cover, or another topic you are interested in). The paper should

be around 10 pages, but there is no strict length requirement. The goal of the project is to partiall to help students explore the literature, so citation of primary research publications is a requirement for a good grade. To make sure the topic is appropriate please consult with me or send an e-mail by the week following the second exam. The paper will be due on the last day of class (this serves as your official notice of such).

Grading

The following weights will be used to determine final grade:

20% Homework

20% Class participation (including presentation of homework)

30% Exams

30% Final Project

Homework will be scored on a standard scale with $90\% = \text{A}$, $80\% = \text{B}$, etc. In addtion to the 5% typesetting bonus, there will be extra credit problems available from time to time. Class participation will be a pass/fail score for each homework problem presented. Exams will be scored on a scale determined from the exam difficulty, but never worse than the standard scale. The final project will be evaluated based on appropriateness of the topic, quality of the report, and the relevance of the bibliography.

Schedule (subject to change)

First exam: Feb 10, 2017
Topic selection for final project: March 10, 2017
Second exam: March 17, 2017
Spring break: March 20-24,2017
Last day of class (project due): April 24, 2017
Final exam: May 1, 2017 8:00 AM