OPTI 573- Atomic and Molecular Spectroscopy for Experimentalists I

Course Description:

Experimental techniques to generate, analyze and detect photons from X-ray to infrared; interpretation of spectra from gases, liquids, solids and biological macromolecules; light scattering, polarization. Graduate-level requirements include homework problem assignments at an advanced level.

Grading Policy:

The grade for the course will be determined from an extensive problem set, a short paper and an oral exam.

To do justice to this course and get an A you must do the following:

1. Satisfactorily complete an 85 problem homework set.
2. Write a three page paper on a topic you choose related to the course.
3. Pass an oral exam covering the homework problem set.

There will be no quizzes, in class exams or final exam.

- The 85 problem homework set is worth 90%
- The paper and oral exam are worth 10%

If you do all the work and do it right, you will get an A.

Homework problems will be due in three parts. They should be handed in on time.

- Part 1: Problems 1-30 -- due on the class date before Oct 15
- Part 2: Problems 30-60 and lab manual questions -- due on the class date before Nov 30
- Part 3: Problems 60-85 and 3-page paper -- due two class periods before the last day of class

The quality of each solution will be indicated by the number of points subtracted from it. For example: If you lose 2 points on a 20 point problem it will get a grade of -2/20. If you lose 7 points on a 10 point problem it will get a grade of -7/10. Problems not done will get a 0 = all points subtracted. I will take these grades into account to determine your percentage grade for the entire homework set. For example it might be 75. This means your grade as it stands now, is 75% and it is worth a C. I will try to indicate where you went wrong on each problem so you can fix it up.

I will grade your problem sets and return them to you so you can correct your mistakes and ultimately do satisfactory work on all of them - if you want to. By the official date of the final exam, all corrected problems should be returned to me for final grading.

The first homework set will be returned for corrections.

- The second and third set might not. Therefore you should do them right the-first time.
- All problems are due by 5 PM of the last day of classes. These can be put in my mailbox.
- Everyone is encouraged to discuss any of the problems with me - in my office or in class.
- All students should meet with me before the last 3 weeks of the semester to discuss problems.
- No incomplete grades of "I" will be given unless negotiated in advance.

These problems cannot be done the night before they are due! Work on them every day, come to class and follow the class notes. They will be invaluable.

Outline

This spectroscopy course is for the experimentalist and the theorist. It deals with the experimental techniques needed to check results predicted by atomic theory. The course develops somewhat historically in the direction of increasing sophistication of both experimental and . theoretical techniques. We start experimentally with spectroscopic plates containing the Balmer lines of hydrogen and Bohr theory and then advance through the following topics:

1. Hydrogen and hydrogen-like systems, isotope effects, radiative recombination, line spectra, continuous spectra, absorption, photoelectric effect, ionization potentials, series limits.
2. Spin-orbit interaction effects on spectra, quantum mechanics of H-like systems, quantum numbers, spectroscopic notation, Pauli principle and the periodic table, mean lives, transition probabilities and oscillator strengths, intensity rules for doublets, selection rules -- electric and magnetic, dipole and quadrupole transitions, forbidden lines, metastable states, two-photon processes.
3. Lande g-factors, Boltzmann statistics, equilibrium, temperature, statistical weights, excitation functions, multiply-excited atoms, complex spectra, polarization, alignment and orientation.

   The above topics will be connected to current research in the field and will provide a working knowledge of spectroscopic notation, spectral line compilations, the NBS-NIST energy level and transition probability tables. Experimental aspects deal with:
4. Gratings, prisms, filters, resolving power, dispersion and speed of spectroscopic systems, spectrometer types -- Wadsworth, Czerny-Turner, Seya-Namoika, grazing incidence, Meinel, Paschen, etc., coupling optical systems, optical fibers, optical speed and f-numbers, instrumental polarization, light sources -- point, line, plane, volume, intense, faint, pulsed, periodic and erratic - in time and space, relative and absolute intensity calibrations. traceable to the NBS-NIST.

5. Stark effect and electric fields, Zeeman effect and magnetic fields, level crossing, Hanle effect, Doppler effect and temperature, the shift and shape of spectral lines, convolutions, atomic, environmental and instrumental line broadening mechanisms.
6. Photomultipliers, photodiodes and CCD's, analog and photon counting techniques, photographic films and plates, strip charts, densitometers, computer acquisition and analysis of data.

   A 1/4-meter Czerny-Turner scanning monochrometer, complete with analog and pulsed electronics, will be available for demonstrations and projects related to the above topics.

Knowledge of the fundamental topics covered in this course is necessary for anyone working with light, color or optical signals -- whether your area of research is astronomy, chemistry, biology, electrical engineering, optical sciences, atmospheric sciences or physics. Throughout the course we constantly investigate how to design and choose the best optical system to make a particular measurement and how to optimize data-taking procedures.