PHYS 689: Modern Atomic Physics (Spring 2016)
3 credit hours, MWF 11:30-12:15 (Room 109)

Instructor - Dr. Hans Schuessler
schuessler@physics.tamu.edu
Office: Mitchell Physics, Room 422
Phone: 979-845-5455
Office hours: Monday, 1-2 and by appointment
Webpage: http://sibor.physics.tamu.edu/

Course (catalog) description
The course is for graduate students interested in research and developments in Atomic Physics. This exciting field has been recognized by many Nobel prizes and touches on several other areas of Science including Chemistry, Nuclear and Astro Physics, Engineering, and the Health and Biosciences. An incredible precision of the measurements has been and is being demonstrated and is enabled by laser cooling and trapping. The laser applications described in this course are spanning from the XUV to the IR spectral ranges, and the dynamics go from continuous wave to attoseconds. A considerable amount of background will be given, with an emphasis on both a full and intuitive understanding, even sometimes at the expense of a rigorous formalism.

Prerequisites
Working knowledge of quantum mechanics, electricity and magnetism, undergraduate-level optics; enrollment by instructor’s consent.

Textbooks
Atomic Physics, Christopher J. Foot (Oxford Master Series in Physics, Oxford University Press 2011)
Atoms, Molecules and Optical Physics 1, Atoms and Spectroscopy, Ingolf V. Hertel and Claus-Peter Schulz (Springer-Verlag Berlin-Heidelberg 2015), ISBN: 978-3-64254321-0

Other recommended textbooks
Ultrashort Laser Pulse Phenomena, by Jean-Claude Diels and Wolfgang Rudolph
Fundamentals of Attosecond Optics, by Zenghu Chang
Frequency-Resolved Optical Gating: The Measurement of Ultrashort Laser Pulses, by Rick Trebino, and his Ultrafast Optics Lecture Notes (available online)

Grading
10% Written homework sets
10% In-Class homework problem presentation
10% Short topic presentation (10 min)
70% Longer (~30 minute) lecture presentation

See http://student-rules.tamu.edu/rule07 for information on University-excused absences.

Topics
1. Basics of atomic physics (week 1)
2. Atomic structure (weeks 2-3)
   a. The hydrogen atom
   b. Helium
   c. Alkalis
   d. LS – coupling
   e. Hyperfine structure and isotope shift
3. Interaction of atoms with light (weeks 4-6)
   a. The rotating wave approximation
   b. Einstein coefficients
c. Bloch vector and Bloch sphere
d. Basic Feynman diagrams
e. Optical pumping

4. Doppler free laser spectroscopy (weeks 7-8)
   a. Doppler broadening
   b. Saturated absorption spectroscopy
   c. On-line laser spectroscopy
   d. Halo nuclei and exotic nucleus shapes

5. Laser cooling and tapping (week 9)
   a. The scattering force
   b. The dipole force
   c. Sisyphus cooling
   d. Sympathetic cooling
   e. Bose-Einstein condensation

6. Ion traps (weeks 10-11)
   a. Paul Dehmelt traps
   b. The Penning trap
   c. The combined trap
   d. Resolved side band cooling

7. Precision spectroscopy with frequency combs (weeks 12-13)
   a. The possible variation of the fundamental constants
   b. The proton radius determination
   c. An atomic fountain
   d. Parity conservation in atoms
   e. Parity non-conservation in anti-atoms

8. High field physics (week 14)
   a. Above threshold ionization
   b. High harmonic generation
   c. Ultrafast time resolved spectroscopy

Homework
Assigned problems will be collected every other week.

Short Topic Presentation: During the course of the semester, you will be asked to make at least one short presentation on a question from a recent lecture, or on current lecture material, as agreed with the instructor.

Lecture Presentation: As part of one of the course lectures, you will need to make a (nominal) 30 min presentation on a subject related to that of the lecture. These lecture presentations will be coordinated in order to distribute them evenly throughout the semester. For extra credit, you may also volunteer to make a 10 min presentation at the end of the semester; this can be a review of an advanced chapter in a textbook, or a selected journal article, or it can be about a problem you are addressing in your research (related to the course material).

ADA statement
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, in Cain Hall, Room B118, or call 979-845-1637. For additional information visit http://disability.tamu.edu.

Academic integrity