Physics 601, Advanced Atomic Physics, Spring 2010

Instructor: Joseph Macek

Time: M–W–F: 11:15-12:05

Place: Phy 608

Text: Theoretical Atomic Physics, by Harald Friedrich, Springer publishing co. 1991,1998, 2002.

I. REVIEW OF NON-RELATIVISTIC QUANTUM MECHANICS

A. Multiparticle quantum mechanics

1. Fields

2. Particles

3. Probability

B. Coulomb potential (hydrogen-like ions)

1. Bound states-the spectrum of atomic hydrogen

2. Continuum states-Rutherford scattering

C. The harmonic oscillator

1. 1,2 and 3 dimensions

2. Constant magnetic field

D. Quantum theory of angular momentum (?)

E. Approximation methods (?)

1. Time-independent perturbation theory

2. Variational methods

3. WKB and semiclassical methods

II. ATOMS AND IONS

A. One-electron species

B. Dirac's equation

1. Solutions for a radial potential

2. Solutions for the hydrogen atom

C. Non-relativistic approximation

1. One-electon species

2. Many-electron species

D. Many-electron systems

1. Pauli principle and Slater determinants

2. Matrix elements with Slater determinants

E. Atomic shell structure and independent particle models

1. Classification of atomic levels

2. Hund's rules

3. Hartree-Fock theory

4. Thomas-Fermi Model and Density Functional Theory

III. ELECTROMAGNETIC TRANSITIONS AND PHOTONS

A. Photons

B. Emission and absorption of photons

IV. ATOMIC SCATTERING

V. TIME-DEPENDENT PROCESSES

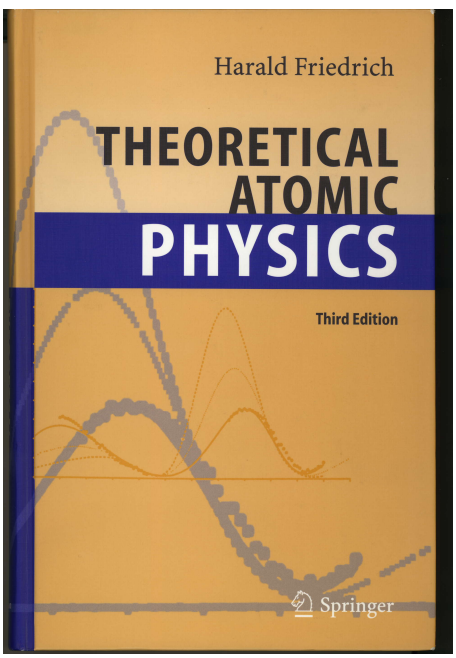
A. Electromagnetic fields

B. Ion-atom collisions

The question marks above indicate that the topics will be covered if there is sufficient demand.

Notes on text: There may be used versions of editions 1 and 2 available. These are acceptable, however, the first edition lacks answers to the problems. Note that the book is available as an ebook. PDFs of the entire book are available at the link

http://proxy.lib.utk.edu:90/login?url=http://dx.doi.org/10.1007/3-540-29278-0



Course organization: There will be a weekly homework assignment, with homework collected on Wednesday of each week. The homework will be graded and returned the next week. Homework counts 30% towards the final grade. A midterm exam at a date suitable for the class will be given. It will also count 30% towards the final grade. A final exam will count 40% towards the course grade.

Course objectives

The main objective of this course is to examine the theoretical basis for our present understanding of the structure of matter at the atomic and molecular level. To that end we will review those aspects of quantum mechanics that play the most important role in this understanding. This includes the structure of simple two-particle species, the properties of bound and continuum states, the quantum theory of many-electron species, the quantum theory of scattering and transitions between energy eigenstates due to electromagnetic interactions. Students should come away from this class with a good grasp of the application of quantum mechanics in physics and some knowledge of atomic structure.