PHYSICS - 607: **FALL - 2006**

MODERN ATOMIC AND NUCLEAR PHYSICS

- **Instructor: Dr. Igor Ostrovskii**

SYLLABUS

➢ COURSE OBJECTIVES AND GOALS:

1. Introduce the physics graduate students to 20-th century atomic and nuclear physics.
2. To give main results in the atomic and molecular spectroscopy, and contemporary nuclear physics.
3. Expand an understanding of the applications of quantum physics to the atoms and nuclei.
4. Develop an understanding of the current basis of broad knowledge in atomic and nuclear physics.
5. To discuss the connections between quantum mechanics and some contemporary problems in physics.
6. Enhance the critical thinking, analytical reasoning, and problem solving skills of graduate level.
7. Discuss the problems confronting physics in the 21-st century.

➢ LEARNING OBJECTIVES:

In this course, we introduce the physics graduate students to the latest achievements in Modern Atomic and Nuclear physics.

- A. The learning outcomes for graduate students are summarized below;
- After completing this course, a student should:

8. Know in detail what is today's "Modern Atomic and Nuclear Physics" including fine optical spectra of atoms and structure of nuclei.
9. Graduates will understand the latest theoretical and experimental results along with 20^{th} century developments in the field of "atomic spectroscopy."
10. Graduate students will be able to apply theoretical results of Quantum physics to an analysis of the experimental data on atomic and nuclear structure.
11. Learners should know how to use interactive methods and Internet for their independent learning in the fields covered by this graduate course.
12. Different learning expectations for graduate versus undergraduate students will be realized (*section B below*).
13. The graduates will contribute to their field of study (*section C below*).

- B. Different learning expectations for graduate versus undergraduate students:

1. Theoretical and experimental results on "atomic spectroscopy" will be understood to a level that helps graduate to pass a comprehensive examination.
2. In class, discussions of the Nobel Prize arts/works in the fields specified will foster broad knowledge of graduates and especially will help them to pass an oral part of comprehensive examination.
3. Graduate students will be able to work out the particular problems of respectively high theoretical level that is needed to take successfully the comprehensive examinations.

4. Doctor and Master Candidates will build on their critical thinking including "how to apply contemporary results to your individual work on a dissertation or thesis."

- C. Fostering independent learning that enable the graduate to contribute to a profession or field of study:

1. Graduate students will make at least one presentation of a certain section/subsection from their textbook to foster independent learning and to train teachers' skills.
2. Graduates will have some special laboratory demonstrations fostering their practical experimental skills in the fields specified.
3. Learners will have an opportunity to present shortly their research themes, literature reviews, etc., which enable graduates to contribute to their field of study, dissertation/theses.

- **Lecture:** TTh 11:00 am – 12:15, Room 126 Lewis Hall
- Office: Room 207 Lewis Hall; Email: iostrov@phy.olemiss.edu
- Office Hours: MWTh 3:30 p.m. – 4:30 p.m. (207 Lewis Hall)

- **TEXT**: Modern Atomic and Nuclear Physics, by Fujia Yang and Joseph H. Hamilton, 2000 or 1996 year edition, McGraw-Hill Companies.

We will cover Chapters 2, 3, 4, 5, 6, 9, 10, 11, 12, 14.

PLEASE, READ THE BOOK

- **Additional reading**: 1) Physics of Atoms and Molecules by B.H. Brandsen and C.J. Joachain, 2nd edition, 2003, Pearson Education Ltd., England. 2) Principles of Modern Physics, by Robert B. Leighton, McGraw-Hill Book Company.

- **GRADING SCALE:** A's ---------- 90 – 100
  B's ---------- 80 – 89
  C's ---------- 70 – 79, Etc.

- **EVALUATION**: Grades will be based on the home works, tests, and final examination:
  Homework ---------- 15 %
  Three tests ---------- 45 % (#1=15%, #2=15%, #3=15%)
  Final exam ---------- 40 %
  100 %

- **TESTS AND FINAL EXAMINATION SCHEDULE:**
  Test 1 (Class # 9), Chapters 2, 3, 4. ------- Tuesday, September 19.
  Test 2 (Class # 18), Chapters 5, 6. ---------- Thursday, October 19.
  Test 3 (Class # 26), Chapters 9, 10, 11.----- Thursday, November 16.

- **FINAL EXAMINATION ---------- Thursday, December 7, 8:00 a.m.**

- **REQUIREMENTS OF THE COURSE AND HOMEWORK RULES:**

1. The basic knowledge of calculus based General Physics, Differential Equations and Math-Methods are required. Undergraduate Quantum Mechanics is a good support for understanding of Phys-617.
2. Homework is assigned after some sections are covered.
3. Homework paper should be 8.5 x 11 inches with no torn or tattered edges.
4. Show all your work; the answer alone is not worth anything. Homework problems must include enough English to be understandable.
5. Homework answers should have units and a reasonable number of significant digits.
6. **Circle the finale answers that you want to be graded.**

COURSE DESCRIPTION AND CONTENTS:

The course of Modern Atomic and Nuclear Physics is devoted to the main experimental and theoretical results in atomic, molecular and subatomic physics, which were achieved in the 20-th century. The PHYS-617 gives a basic knowledge in the a) atomic configuration and atomic spectroscopy including fine structure in atomic spectra; b) X-Rays spectroscopy; c) basic concepts of nuclear physics including radioactive decay, nuclear forces, nuclear interactions and reactions. The applications of quantum mechanics to the atoms, molecules and spectroscopy are discussed.

PART 1:

1. (Ch. 2) The Configuration of the Atom: Background, The Rutherford Model, The Rutherford Scattering formula.
2. (Ch. 3) Quantum States of Atoms: The Bohr Model, Experimental evidences, Frank-Hertz experiment, Bohr-Sommerfeld model.
3. (Ch. 4) Fine Structure in Atomic Spectra: Magnetic orbital moment, Stern-Gerlah experiment, Spin of electron, Zeeman Effect.

- **Test 1 (Class # 9), Chapters 2, 3, 4. ---------- Tuesday, September 19.**

PART 2:

4. (Ch. 5) Atoms Containing Many Electrons: Helium, Coupling of two electrons, The Pauli Exclusion Principle, The Periodic Table of Elements.
5. (Ch. 6) X-Rays: Discovery of X-Rays, Mechanisms for producing X-Rays, Compton Scattering, Absorption of X-Rays.

- **Test 2 (Class # 18), Chapters 5, 6. ---------- Thursday, October 19.**

PART 3:

6. (Ch. 9) Basic Concepts of Nuclear Physics: Nucleus of atom, Properties at ground state, Ground state spins and moments.
7. (Ch. 10) Radioactive Decay: Decay Laws, Alpha and Proton fission decays, Beta decay, Gamma decay.
8. (Ch. 11) Nuclear Forces and Nuclear Models: Nuclear forces, Models, Toward a Unified Model to describe the properties of the nuclei.

- **Test 3 (Class # 26), Chapters 9, 10, 11.-------- Thursday, November 16.**

9. (Ch. 12) Nuclear Interactions and Reactions: Reaction Kinematics, Reactions, Fission, and Fusion, Applications of Nuclear Physics.
10. REVIEW: (Ch. 14) High-Energy Physics: Particle Families and Interactions, Conservation Laws, The Quark Model.

(Last class # 28 on Thursday, November 30, 2006).

- **FINAL EXAMINATION ---------- Thursday, December 7, 8:00 a.m.**

- - The dates of chapter tests are tentative and may be changed, but NOT THE FINAL EXAMINATION DATE/TIME.