The following classroom policies have been prescribed by the University of Mississippi during Fall 2021 in response to the COVID-19 Pandemic:

- **Students are expected to comply with the University's protocols when they are in effect. Currently, a mask requirement is in place for vaccinated and unvaccinated people. As a result, proper mask wearing is required indoors and in the classroom.** Current protocols can be found at https://coronavirus.olemiss.edu/.
- Students who have a diagnosed health concern that interferes with the wearing of face masks may contact the Student Disabilities Services (SDS) Office to seek a University-approved accommodation. Please contact SDS at https://sds.olemiss.edu/for more information.
- If students test positive for COVID-19 at any health care facility, they must contact the Student Health Center at 662-915-7274. (Faculty and staff should contact the Employee Health Service at 662-915-6550.) University Health Services will coordinate contact tracing to lessen the likelihood of spread.
- Students with COVID-19 should seek medical attention at the Student Health Center and contact their instructor to let them know that they will be missing class due to a health-related issue.
- If you are exposed to someone with COVID-19, you should contact the Student Health Center to get tested three to five days following exposure and follow the guidance recommended by the Health Center. If you are not fully vaccinated, you should follow quarantine protocols found athttps://coronavirus.olemiss.edu/students/.
- **Currently, COVID-19 guidelines for the Fall 2021 semester include face masks for vaccinated and unvaccinated people inside University buildings; therefore, students should not be in classroom spaces when they are out of compliance with these guidelines unless they have an accommodation approved by Student Disability Services.**
- **The University's Academic Conduct and Discipline Policy states that "disorderly behavior that disrupts the academic environment violates the standard of fair access to the academic experience." Failure to adhere to health requirements during the COVID-19 emergency will be deemed as disruptive to the classroom and will be enforced following the Academic Conduct and Discipline procedures.**
- The University of Mississippi has adopted a tiered disciplinary protocol for non-adherence to COVID-19 health requirements. This disciplinary protocol is maintained by the Office of Conflict Resolution and Student Conduct: https://conflictresolution.olemiss.edu/covidupdates.

- **COURSE: Phys-607 Atomic and Nuclear Physics Dr. Ostrovskii Fall 2021**

LECTURES: 8/24-12/02, T TH at 09:30-10:45 AM, Dr. OSTROVSKII, IGOR Room Lewis 104

- **Instructor: Dr. Ostrovskii**
- **Lecture: Tu, Th** 09:30-10:45 AM**, Room 104 Lewis Hall**
- **Office: Room 207 Lewis Hall**; Email: iostrov@phy.olemiss.edu
- **Office Hours**: **Th 3:15 p.m. – 4:15 p.m**., and by appointment

TEXT: The Physics of Atoms and Quanta, by H. Haken and H.C. Wolf, 7-th edition, Springer.
ISBN: 9783540208075

We will cover Chapters 1 through 20. PLEASE, READ THE TEXT

Additional reading: 1) Modern Atomic and Nuclear Physics, by Fujia Yang and Joseph H. Hamilton, McGraw-Hill

1. General description of the course's purpose.

- Introduce the physics graduate students to the latest achievements in Atomic and Nuclear physics.
- Present the main results of the atomic and nuclear physics in 20th and 21st centuries.
- Expand an understanding of the applications of quantum physics to the atoms and nuclei.
- Develop an understanding of contemporary atomic and nuclear physics including a broad spectrum of topics of current and emerging interest in physics.
- *Enhance the critical thinking, analytical reasoning, and problem-solving skills of graduate level.*
- To give the brief sketches of some historical developments in atomic and nuclear physics in the 20th and 21st centuries.
- To use of the Internet, Interactive demos, Lecture demonstrations, and scientific publications for assuring *in-depth understanding of the matter*. Discuss the problems confronting physics in the 21-st century.
- Develop in learners an ability to *present orally their scientific knowledge*, which will be achieved with the help of student scientific presentations.

2. The learning objectives of the course.

In the learning objectives, we answer a question: "What will the students know and be able to do as a result of taking this class and passing the final examination."

After completing this course, a graduate student should be able to:

- Explain in detail the topics in "Modern Atomic and Nuclear Physics" including interaction of quanta with atoms, fine optical spectra, and structure of nuclei.
- Graduates will understand the latest theoretical and experimental results along with $20^{th}/21^{st}$ century developments in the field of "atomic spectroscopy."
- Graduate students will be able to apply theoretical results of Quantum physics to analysis of the experimental data on atomic and nuclear structure. Learners should know how to use interactive methods and Internet for their independent learning in the fields covered by this graduate course. The graduates will contribute to their field of study (*paragraph below*).

Different learning expectations for graduate versus undergraduate students:

- Theoretical and experimental results on "atomic and nuclear structure" will be understood at a level that helps graduate to pass a comprehensive examination and successfully accomplish their graduate research projects.
- In class, discussions of the Nobel Prizes in the fields specified will foster broad knowledge of the graduate students and especially will help them to pass an oral part of comprehensive examination.
- Doctor and Master-Science Candidates will build on their critical thinking including "how to apply contemporary results to your individual work on a dissertation/thesis."
- *Fostering independent learning* that enables the graduates to contribute to a profession or field of study: A) 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. B) Graduates will have some laboratory demonstrations fostering their practical experimental skills in the fields specified. C) Learners will have an opportunity to present shortly their research themes, literature reviews, etc., which enable graduates to contribute to their field of study including topics of their future dissertations/theses.

3. Description of Examinations

Test # 1 (Class # 11), Chapters: 2, 3, 4, 5, 6, 8, 1 1 --- Tuesday, September 28, 2021.
Test # 2 (Class # 22), Chapters 12 – 17 --- Thursday, November 4, 2021.
FINAL EXAMINATION ---------- Thursday, December 9, 8:00 –11:20 AM, 2021.

4. Information about the grading process and standards.

- **A's ----- 89 – 100// B's --- 79 – 88 // C's ---- 69 – 78 // D's ---- 59 – 68**
- **EVALUATION**: Grades will be based on the home works, tests, presentation, class activity and final examination; plus, and minus system of A, A-, B+, B-, etc. may be applied.
- **Points**: **Home works --17 points // Two tests--- 38 points (2-chapter tests x 19 points each)**
  Presentation --- 10 points // Class activity --- 10 points for zero university-unrelated absences,
  3) ***Final exam --- 25 points //*** **TOTAL = 100 points**

5. General description of covered topics.

PART 1:

Ch.1. Introduction [0.5 class]

Ch. 2. The Mass and Size of the Atom. [1 classes]
Determination of the Mass. Methods for Determining Avogadro's number.
Determination of the Size of the Atom. Can Individual Atoms Be Seen?

Ch. 3. Isotopes. [1 class]
The Periodic System of the Elements. Mass Spectroscopy. Modern Applications of the Mass Spectrometer. +SIMS.

Ch. 4. The Nucleus of the Atom. [1 class]
Passage of Electrons through Matter. Passage of Alpha Particles through Matter; Rutherford scattering.

Ch.5. The Photon. [1.5 class]
Wave Character of Light. Thermal Radiation.The Photoelectric Effect. The Compton Effect.

Ch. 6. The Electron. [1 class]
Production of Free Electrons. Size of the Electron. The Charge of the Electron. The Specific Charge q/m. Wave

Character of Electrons and Other Particles. Interferometry with Atoms.

Ch. 7. Overview & Ch.8. Bohr's Model of the Hydrogen Atom. [2.5 classes]
Basic Principles of Spectroscopy & Optical Spectrum of the Hydrogen Atom.
Some Quantitative Conclusions. Motion of the Nucleus. Spectra of Hydrogen-like Atoms. Muonic Atoms. Excitation of Quantum Jumps by Collisions. Sommerfeld's Extension and the Experimental Justification of a Second Quantum Number. Orbital Degeneracy and the Relativistic Mass Change. Rydberg Atoms. Exotic Atoms: Positronium, Muonium, and Antihydrogen.

Ch.11. Lifting of the Orbital Degeneracy in the Spectra of Alkali Atoms. [1.5 classes]
Shell Structure. Screening. The Term Diagram. Inner Shells.

Test # 1 (Class # 11), Chapters: 2, 3, 4, 5, 6, 8, 11 ------ Tuesday, September 28, 2021.

PART 2:

Ch.12. Orbital and Spin Magnetism. Fine Structure. [2.5 classes]
Magnetic Moment of the Orbital Motion. Precession and Orientation in a Magnetic Field.
Einstein-de Haas Method. Detection of Directional Quantization by Stern and Gerlach.
Fine Structure. Calculation of Spin-Orbit Splitting. Level Scheme of the Alkali Atoms.
Fine Structure in the Hydrogen Atom. The Lamb Shift.

Ch. 13. Atoms in a Magnetic Field. [1.5 classes]
Experiments and Their Semi-classical Description: Directional Quantization in a Magnetic Field. Electron Spin Resonance. The Zeeman Effect. The Vector Model. The Pashen-Back Effect. Double Resonance (+ODMR). + Giant Magneto-resistance. + Spin Microscope.

Ch. 14. Overview & Ch. 15. Atoms in an Electric Field. [2 classes]
Quantum theory of the Zeeman Effect. Quantum theoretical treatment of the electron and proton spins. Observation of the Stark Effect. Theory of the Stark Effect. Spin and Photon Echoes.

Ch. 16. General Laws of Optical Transitions. [1 class]
Symmetries and Selection Rules. Optical Matrix Elements. Symmetry behavior of Wave functions. Selection Rules.

Ch. 17. Many-Electron Atoms. [3 classes]
The Spectrum of the Helium Atom. Electron Repulsion and the Pauli Principle. Angular Momentum Coupling. Russell-Saunders Coupling and *JJ* Coupling. Magnetic Moments of Many-Electron Atoms. Multiple Excitations.

Test # 2 (Class # 22), Chapters 12 – 17 --- Thursday, November 4, 2021.

PART 3:

Ch. 18. X-Ray Spectra, Internal Shells. [1.5 classes]
X-Radiation from Outer Shells. X-Ray Bremsstrahlung Spectra. Emission Line Spectra: Characteristic Radiation. Fine Structure of the X-Ray Spectra. Absorption Spectra. The Auger Effect. Photoelectron Spectroscopy (XPS), ESCA.

Ch. 19. Structure of the Periodic System. Ground States of the Elements. [1.5 classes]
Periodic System and Shell Structure. From the Electron Configuration to the Atomic Term Scheme. Atomic Ground States. Excited States of Atoms and Possible Electronic Configurations.

Ch. 20A. Nuclear Spin, hyperfine Structure (Sns. 20.1, 2, 3). [1class]

Ch. 20B. ***Student Presentations of*** **Ch. 20.** Nuclear Spin, hyperfine Structure (Sns. 20.4-20.8). [2 classes]

FINAL EXAMINATION ---------- Thursday, December 9, 8:00 – 11:20 AM, 2021.

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

6. Other student requirements

Lecture and test requirements: PLEASE, turn off your phone before class!

- It is not allowed to use of any smart devices (smartphones, programmable calculators, etc.) during exams.
- Any recording in class is in contradiction with the Copyright Law and is not permitted, unless authorized by SDS.
- ***Note taking skills should be developed.*** Please make your own lecture notes.
- Absence may jeopardize your standing because you are responsible for any in-class activities**.**

- ***Academic integrity***: While in class, you are expected to attend to and participate in discussion (no private conversation or other behaviors that would disrupt class activities).
- You are expected to be civil to others in the class.

Homework requirements:

- Homework is assigned after some sections are covered and is due in a week.
- Homework paper should be 8.5 x 11 inches with no torn or tattered edges.
- Homework papers should be stapled allowing their reading and grading.
- Show all your work; the answer alone is not worth anything. The answers in numbers must have **one additional digit** after a decimal point in comparison to text's "Solutions to the Problems." **This additional digit will be graded as well.**
- **Homework papers must include**: diagrams, equations, derivations, calculations, and explanations of what you are doing / reasoning, ***enough English*** to be understandable.
- Homework answers should have units and a reasonable number of significant digits.
- **Encircle** the answers that you want to be graded. ***(If Nothing is encircled -> Nothing is graded*)**.
-

7. Fostering independent learning:

1. Discuss the problems confronting Atomic and Nuclear physics in the 21-st century based on the results developed mainly in the 2nd half of 20th century.

2.Learners will be recommended additional reading including texts, monographs, and particular Journal publications.

B. To ensure ongoing graduate student engagement in research:

3. Since in this course we introduce the graduates to the latest results in "Atomic and Nuclear Physics," they will have enough knowledge to understand contemporary needs in new high-technology applications and practical solutions.

4. The learners may give a talk on latest results in the field, for example, "Nobel Prize in Physics", and modern applications in the field, etc.

C. To ensure appropriate professional practice and training experience:

5. When teach the physical basis of major contemporary applications of "Atomic and Nuclear Physics", to prompt learners to search for the publications in the scientific Journals for a particular physics phenomenon or effect.

6. Graduate students will know how to use interactive methods and Internet for their independent learning on "Solid State Physics I" especially those parts that describe the latest results in Solid State and its contemporary applications.

7. Learners will make the appropriate scientific presentations.

8. ***The Faculty Senate*** produced the document, which encourages faculty members to include the following text in their syllabi: *"All materials distributed electronically and in hard copy in this class are protected under intellectual copyright. Any attempt to upload these documents onto the Internet (or to distribute them by some other means) or to profit from the distribution (by Internet or other means) of these documents constitutes theft and will be in violation of intellectual property law and the UM Academic Conduct Code unless expressly permitted for by the instructor. Accessing such materials for your own use is also in violation of the UM Academic Conduct Code. Additionally, the distribution of your own class notes via the Internet or other means, or access of such materials, encourages absence from class and is highly discouraged."*

9. ***UM Attendance guidelines:*** If a **student informs** an instructor in advance about an anticipated absence and the instructor decides not to provide an accommodation for a major exam or assessment, the student may appeal to the department chair or program director (or dean, when the instructor is chair or program director) who oversees the course. An appeal must be based on **(a)** failure of the instructor to articulate a policy, **(b)** failure of the instructor to follow the articulated policy, or **(c)** failure by the instructor to offer a reasonable accommodation for a documented absence that caused a student to miss an assessment that is **worth 20% or more of the course grade**.[Based on UM "Class Attendance Guidelines,"**- No accommodations for missed chapter tests will be made.**]