Course Syllabus

Course Information

PHYSICS 4302: Quantum Mechanics II
Section 001: January 14 – May 4, 2013
Classes: TR 4:00 pm – 5:15 pm in FN 2.104

Contact Information

INSTRUCTOR: Dr. Yuri Gartstein					
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Office hours: TBA			Extra classroom hours: As needed		

Course Pre-requisites, Co-requisites, and/or Other Restrictions

Pre-requisite: PHYS 4301. It is assumed that students are comfortable with all the math used in PHYS 4301, such as elements of linear algebra, differential equations, eigenvalue problems, complex numbers, and multivariable calculus. While some math discussions may be taking place during the course, students are advised to keep their skills polished by accessing any comprehensive book on mathematical methods in Physics.

Goals and Student Learning Objectives/Outcomes

This course is to continue student's acquaintance with Quantum Physics with the goal of fostering appreciation of the role quantum mechanics plays in understanding the world of our experience. As the notions and pictures offered by quantum mechanics are so radically different from what we are used to in "macroscopic" classical physics, it is very important to (try to) develop intuitive personal feeling of the subject by examining various examples of how quantum mechanics actually works, "the dirty real world of everyday applications of quantum mechanics" (Harry Lipkin). Many of realistic (and very interesting) applications would however lead to nearly insurmountable mathematical difficulties if addressed "straightforwardly". Moreover, perhaps lost in such a pursuit could be that "simple physical picture" one tried to attain.

Fortunately, quantum mechanics also features a lot of powerful (and insightful) methods that allow us to derive answers to important questions and, simultaneously, build a framework of notions that are very helpful in "intuitive rationalization" of quantum-mechanical results. A similar role may also be played by analyses of simplified model systems. In this course, the student will be exposed to different approximations and approaches of this kind that we will immediately put to "pragmatic use" by addressing various significant questions. Such as, e.g., the formation of chemical bonds or the nature of Van der Waals attractive forces. Or how the absorption and emission of light takes place. Or the nature of the difference between metals and insulators. And we will continue to discuss examples of great qualitative differences between quantum results and classical expectations. Such as how the outcome of the spin-independent Coulomb repulsion between two electrons actually depends on the total spin of the pair. Or how

physically auxiliary electromagnetic potentials (as opposed to the fields) in classical physics can actually lead to observable consequences in quantum mechanics.

"Ideally", upon completion of the course, the instructor would like to see students be able not only to apply specific methods we will discuss but also to provide qualitative explanations and interpretations of the effects and phenomena (how "quantum things" work) that perhaps even a layman would understand. Another desirable outcome is further appreciation of the relationship between mathematics and physical reality and subsequent strengthening of problem-solving skills. Hence, our focus will be on conceptual understanding as applied to problem solving. Students are expected to spend as much as possible of their own time on examples and problems including beyond discussions in the classroom.

Course Description

This brief high-level description is intended to give a glimpse of some of the subjects we will be talking about. They are listed here not in the order we would be addressing them. A more detailed listing of topics and notions will be made available online. The depth of discussion of some of the topics will be influenced by the actual pace of our progress in the course.

METHODS AND APPROACHES

Time-independent and time-dependent perturbations; Transitions between quantum states and Fermi's golden rule; Adiabatic (slow) and sudden perturbations; Semi-classical (WKB) approximation and tunneling; Variational method; Separation of slow and fast degrees of freedom and adiabatic potential surfaces; Born approximation and scattering amplitudes; Linear combinations of atomic orbitals and tight-binding approximation.

SYSTEMS AND INTERACTIONS

Atoms and molecules; Fine structure and of atomic spectra and Zeeman effect; Stark effect; Interacting oscillators and Van der Waals forces; Hydrogen ion and molecule; Chemical bonds and hybridization; Charged particles in the electromagnetic field; Landau levels; Absorption and emission of radiation by oscillators and bound systems, Two-level systems: magnetic resonance and optical absorption line shape; Scattering by periodic potentials, allowed and forbidden energy bands; Electronic structure of solids.

PARTICLES, SYMMETRIES AND GEOMETRY

Indistinguishibility of identical particles and symmetry of wave functions; Pauli exclusion principle and Slater determinants; Exchange interaction and singlet-triplet splitting; Collisions of identical particles; Bose and Fermi statistics; Geometrical symmetry and selection rules; Dynamical and geometric phases; Electromagnetic potentials in quantum mechanics: Aharonov-Bohm effect.

Textbooks and Materials

In all likelihood, the book(s) you used for QM I would be quite adequate for QM II as well. This course is not going to literally follow the exposition in a single specific textbook so your lecture notes are expected to be a helpful resource in relating to your reading materials. There are many, "old" and "new", good books that cover various aspects of QM essentials and in different styles. Listed below are some of these textbooks; they are directed towards beginners, and you may find one of them particularly appealing to you personally.

- **"Introduction to Quantum Mechanics"** by **David Griffiths**. One of widely used and generally liked textbooks, frequently a standard at UTD. I cannot exclude that this book would be considered as appropriate by the majority of the students.
- **"Quantum Mechanics for Scientists and Engineers"** by **David Miller.** A very recent and nice textbook from Stanford that has a lot of connections to modern technology applications.
- **"Quantum Mechanics. Concepts and Applications"** by **Nouredine Zettili**. A textbook that features tons of worked out examples and problems.
- **"Quantum Mechanics. An Introduction"** by **Walter Greiner**. The first book in a series by this author that represents a nice example of "German" textbook scholarship.

When and if you may need extra materials for some specific topics, I would be happy to offer my advice.

Assignments, Evaluation and Grading Policy

In accordance with the course objectives, conceptual understanding and ability to apply principles to actual problem solving is the key to your success. The final grade will be contributed to by the following ingredients: results of two exams (including final), homework, and individual participation in classroom discussions.

- The homework results will contribute approximately 60% to the final grade. The instructor believes that persistent (as opposed to sporadic) engagement with the course material is vitally important, hence a large homework contribution to stimulate such behavior. Homework assignments will be posted on eLearning and may include not only problems but also self-study topics. The homework must be submitted by the due date but extra specified time may be given to provide improved solutions. Consistent performance here can therefore build a foundation for a satisfying final grade.
- Midterm and final written exams, each contributing about 20% to the final grade, consist of problems, no multiple choice questions will be given. The midterm exam may be in the *take-home* mode. The **final exam** is on the UTD schedule (**May 9** at **2:00 pm**) and takes place in the classroom. When in the classroom, exams are open book. In all cases, a student **should be able** to explain his/her solutions.
- Select questions/problems/topics including from homework will be discussed in class with individual students asked to present, lead and participate in such discussions. The instructor reserves up to 10% of the final grade as bonus points to reward meaningful student contributions. The corollary here is that one would like to be always prepared.

Course & Instructor Policies

Every attempt will be made to give students an opportunity to improve their standing. As mentioned above, this includes the possibility to resubmit homework assignments. Results of exams are open for individual discussions. All questions about grades should be addressed the same week the grades become known. All special student needs should be reported within first two weeks of the course. Communication of all grades and announcements will be through eLearning, it is the **responsibility of students** to regularly check their eLearning pages and email.

A proactive student's position in and out of the classroom is encouraged and expected, and your feedback is always welcome. Attendance of lectures is strongly advised but not required. The integrity of students' behavior matters - working in groups and using various materials is encouraged but it is the individual understanding of the subject and results that will be tested.

Last but not least, the instructor strongly feels that satisfaction one gets from the learning accomplishments makes "grades" a much less sensitive issue. My general position is that "I am here not to make your life harder but to help you learn". I would like to invite all students to have more fun from learning and worry less about grading.

Off-campus Instruction and Course Activities

Off-campus, out-of-state, and foreign instruction and activities are subject to state law and University policies and procedures regarding travel and risk-related activities. Information regarding these rules and regulations may be found at the website address http://www.utdallas.edu/BusinessAffairs/Travel_Risk_Activities.htm. Additional information is available from the office of the school dean.

Student Conduct & Discipline

The University of Texas System and The University of Texas at Dallas have rules and regulations for the orderly and efficient conduct of their business. It is the responsibility of each student and each student organization to be knowledgeable about the rules and regulations which govern student conduct and activities. General information on student conduct and discipline is contained in the UTD publication, *A to Z Guide*, which is provided to all registered students each academic year. The University of Texas at Dallas administers student discipline within the procedures of recognized and established due process. Procedures are defined and described in the *Rules and Regulations, Board of Regents, The University of Texas System, Part 1, Chapter VI, Section 3*, and in Title V, Rules on Student Services and Activities of the university's *Handbook of Operating Procedures*. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations (SU 1.602, 972/883-6391). A student at the university neither loses the rights nor escapes the responsibilities of citizenship. He or she is expected to obey federal, state, and local laws as well as the Regents' Rules, university regulations, and administrative rules. Students are subject to discipline for violating the standards of conduct whether such conduct takes place on or off campus, or whether civil or criminal penalties are also imposed for such conduct.

Academic Integrity

The faculty expects from its students a high level of responsibility and academic honesty. Because the value of an academic degree depends upon the absolute integrity of the work done by the student for that degree, it is imperative that a student demonstrate a high standard of individual honor in his or her scholastic work.

Scholastic dishonesty includes, but is not limited to, statements, acts or omissions related to applications for enrollment or the award of a degree, and/or the submission as one's own work or material that is not one's own. As a general rule, scholastic dishonesty involves one of the following acts: cheating, plagiarism, collusion and/or falsifying academic records. Students suspected of academic dishonesty are subject to disciplinary proceedings. Plagiarism, especially from the web, from portions of papers for other classes, and from any other source is unacceptable and will be dealt with under the university's policy on plagiarism (see general catalog for details). This course will use the resources of turnitin.com, which searches the web for possible plagiarism and is over 90% effective.

Email Use

The University of Texas at Dallas recognizes the value and efficiency of communication between faculty/staff and students through electronic mail. At the same time, email raises some issues concerning security and the identity of each individual in an email exchange. The university encourages all official student email correspondence be sent only to a student's U.T. Dallas email address and that faculty and staff consider email from students official only if it originates from a UTD student account. This allows the university to maintain a high degree of confidence in the identity of all individual corresponding and the security of the transmitted information. UTD furnishes each student with a free email account that is to be used in all communication with university personnel. The Department of Information Resources at U.T. Dallas provides a method for students to have their U.T. Dallas mail forwarded to other accounts.

Withdrawal from Class

The administration of this institution has set deadlines for withdrawal of any college-level courses. These dates and times are published in that semester's course catalog. Administration procedures must be followed. It is the student's responsibility to handle withdrawal requirements from any class. In other words, I cannot drop or withdraw any student. You must do the proper paperwork to ensure that you will not receive a final grade of "F" in a course if you choose not to attend the class once you are enrolled.

Student Grievance Procedures

Procedures for student grievances are found in Title V, Rules on Student Services and Activities, of the university's *Handbook of Operating Procedures.* In attempting to resolve any student grievance regarding grades, evaluations, or other fulfillments of academic responsibility, it is the obligation of the student first to make a serious effort to resolve the matter with the instructor, supervisor, administrator, or committee with whom the grievance originates (hereafter called "the respondent"). Individual faculty members retain primary responsibility for assigning grades and evaluations. If the matter cannot be resolved at that level, the grievance must be submitted in writing to the respondent

with a copy of the respondent's School Dean. If the matter is not resolved by the written response provided by the respondent, the student may submit a written appeal to the School Dean. If the grievance is not resolved by the School Dean's decision, the student may make a written appeal to the Dean of Graduate or Undergraduate Education, and the deal will appoint and convene an Academic Appeals Panel. The decision of the Academic Appeals Panel is final. The results of the academic appeals process will be distributed to all involved parties. Copies of these rules and regulations are available to students in the Office of the Dean of Students, where staff members are available to assist students in interpreting the rules and regulations.

Incomplete Grade Policy

As per university policy, incomplete grades will be granted only for work unavoidably missed at the semester's end and only if 70% of the course work has been completed. An incomplete grade must be resolved within eight (8) weeks from the first day of the subsequent long semester. If the required work to complete the course and to remove the incomplete grade is not submitted by the specified deadline, the incomplete grade is changed automatically to a grade of **F**.

Disability Services

The goal of Disability Services is to provide students with disabilities educational opportunities equal to those of their non-disabled peers. Disability Services is located in room 1.610 in the Student Union. Office hours are Monday and Thursday, 8:30 a.m. to 6:30 p.m.; Tuesday and Wednesday, 8:30 a.m. to 7:30 p.m.; and Friday, 8:30 a.m. to 5:30 p.m.
The contact information for the Office of Disability Services is:
The University of Texas at Dallas, SU 22
PO Box 830688
Richardson, Texas 75083-0688
(972) 883-2098 (voice or TTY)
Essentially, the law requires that colleges and universities make those reasonable adjustments necessary to eliminate discrimination on the basis of disability. For example, it may be necessary to remove classroom prohibitions against tape recorders or animals (in the case of dog guides) for students who are blind. Occasionally an assignment requirement may be substituted (for example, a research paper versus an oral presentation for a student who is hearing impaired). Classes enrolled students with mobility impairments may have to be rescheduled in accessible facilities. The college or university may need to provide special services such as registration, note-taking, or mobility assistance.
It is the student's responsibility to notify his or her professors of the need for such an accommodation. Disability Services provides students with letters to present to faculty members to verify that the student has a disability and needs accommodations. Individuals requiring special accommodation should contact the professor after class or during office hours.

Religious Holy Days

The University of Texas at Dallas will excuse a student from class or other required activities for the travel to and observance of a religious holy day for a religion whose places of worship are exempt from property tax under Section 11.20, Tax Code, Texas Code Annotated. The student is encouraged to notify the instructor or activity sponsor as soon as possible regarding the absence, preferably in advance of the assignment. The student, so excused, will be allowed to take the exam or complete the assignment within a reasonable time after the absence: a period equal to the length of the absence, up to a maximum of one week. A student who notifies the instructor and completes any missed exam or assignment may not be penalized for the absence. A student who fails to complete the exam or assignment within the prescribed period may receive a failing grade for that exam or assignment. If a student or an instructor disagrees about the nature of the absence [i.e., for the purpose of observing a religious holy day] or if there is similar disagreement about whether the student has been given a reasonable time to complete any missed assignments or examinations, either the student or the instructor may request a ruling from the chief executive officer of the institution, or his or her designee. The chief executive officer or designee must take into account the legislative intent of TEC 51.911(b), and the student and instructor will abide by the decision of the chief executive officer or designee.

These descriptions and timelines are subject to change at the discretion of the Professor.