PHYSICS 4143: QUANTUM MECHANICS I (SPRING 2012)

Schedule for QMI

Instructor: Brian Kennedy, N119 Howey (office hours: W 3-4 pm, or by email appointment)
Assistant: Shuai Sun, shuai.sun3@gmail.com,(office hours: W 2-3 pm and Th 2-3 pm in S102, or by email appointment)
Lectures: MWF 9.05-9.55 am L5

Goals

This is the second of a two semester sequence in quantum mechanics. In Phys 3143 we built up the ideas and formalism of quantum theory, in particular the notions of linear superpositions of states, state preparation and measurement. We employed an extended discussion of the classic Stern-Gerlach experiment as a vehicle for this purpose. This lead us to discuss spin angular momenta and time evolution. We then introduced wave mechanics, a topic you should have seen to some extent in sophomore modern physics.

In Phys 4143 we will begin by reviewing the vector space, matrix and wave mechanical formalism. Our treatment of the simple harmonic oscillator, one of the most important paradigms in classical and quantum physics, will also serve to illustrate the mathematical formalism of quantum theory. We will study how to describe composite quantum systems and systems of identical particles. Finally we will learn how to apply quantum theory to some of the classic problems of quantum physics, such as the structure of atoms and their interaction with applied static and time-dependent electromagnetic fields.

Provisional Syllabus

We may not stick rigidly to this syllabus, but the plan is as follows. The chapter references refer to your related readings in the textbook of Townsend.

Review of mathematical formalism:
The harmonic oscillator (Chapter 7).
Composite spin systems:
Systems of two-spin 1/2 particles. Addition of angular momentum. EPR paradox, Bell inequalities. Entanglement. (Chapter 5.)
Translational and rotational symmetries in 2-body problem:
Wave mechanics in dimension 3. Orbital angular momentum. Central potentials and the hydrogen atom. (Chapters 9 and 10.)
Time-independent perturbation theory:
(Chapter 11)

Identical Particles:
Helium. Variational method. The periodic table. Molecular bonds. Bose-Einstein condensation. Identical fermions. (Chapter 12)

Atoms and Photons - time dependent problems:
Electromagnetic field interactions. Time-dependent perturbation theory. Spontaneous emission. (Chapter 14.)

If time permits we will cover some additional topics e.g., scattering theory, path integrals, JWKB method.

Grading

Homeworks 25 points: Discussing problems with class mates and peers is encouraged, but you should write up your own solutions without assistance. Official homework solutions can be requested for viewing at my (N119) or Shuai Sun's office (lab S102) at any time. You may take notes from these in your own hand writing, but you may not photocopy them.
Class Tests (2) 30 points
Final 45 points
Attendance: Each student should be aware of the regulations that are listed in the student handbook. The class attendance policy, which the Georgia Tech regulations say shall be at the discretion of the instructor, will be as follows: There will be no prescribed maximum number of unexcused absences for this class. When it is apparent, however, that missing class is impairing a student's performance in the course, the instructor may require that the student not miss more classes, or suffer a grade penalty.

Useful References

I have recommended *A modern approach to quantum mechanics, University Science Books, 2000* by John S. Townsend as the course text for the first time this year. The syllabus covers material in various chapters of this text, but the course should not be regarded as a review of the book. *It is therefore essential that each student keeps their own complete set of notes of the lectures.* This text introduces conceptually important issues such as measurement and state preparation at the beginning. It differs from the "wave mechanics first" approach by treating measurement in concrete terms by reference to Stern-Gerlach experiments, and the mathematical formalism is built up first using matrices and linear algebra rather than through differential equations and Fourier series. In Physics 4143 attention turns towards applications of the formalism to various problems, many involving atomic physics, and the use of important approximation techniques like perturbation theory and the variational method.

It is inevitable that some students will not appreciate the style and approach of the text as much as others do; no single text can do justice to the myriad complexities of a subject like quantum mechanics. There are other "undergraduate" level texts that are useful to consult. The most obvious one is the previous class text by Griffiths, which emphasizes a wave mechanics first approach. Among others I would like to highlight, for very different reasons, are the texts by Zettili and Isham. The latter has been very popular with previous generations who have taken my quantum mechanics classes at both undergraduate and graduate level, and is unusually clear in its discussion of the interpretation of quantum theory. The book by Zettili (at least, the first edition with which I am familiar) is characterized by a wide range of explicitly solved problems, and students have told me that they value highly this unusual feature. As an undergraduate I liked Shankar's book, although it is a bit more advanced than Townsend or Griffiths. Feynman's lectures Vol III is a source with some wonderful insights - its point of view is echoed in the presentation of Townsend.

It is important to have at hand a good mathematical reference on calculus, matrices and basic probability (see also the course t-square site for resources). Integration by parts and determination of matrix eigenvalues for example, should be a tool for routine calculation and not a problem in itself. The only way to achieve this is by practice.

*On Reserve at the library

Undergraduate:

*Quantum Physics (3rd edition), 2003 by S. Gasiorowicz
*Quantum Mechanics, Concepts and Applications (2nd edition), 2009 by N. Zettili
*Quantum Mechanics, classical results, modern systems and visualized examples, 1997 by R.W. Robinett.
*Principles of Quantum Mechanics (2nd edition), 1994 by R. Shankar
Quantum Mechanics Vol I and II, 1977 by C. Cohen-Tannoudji, B. Diu and F. Laloe.
Quantum Mechanics, 1992 and Advanced Quantum Mechanics, 1999 by F. Schwabl
Introductory Quantum Mechanics,(4th edition) by R.L. Liboff.
Feynman Lectures Vol III 1965, R.P.Feynman, R.B. Leighton and M. Sands.

Foundational:

*Lectures on quantum theory: mathematical and structural foundations, 1995 by C.J. Isham
Quantum theory: Concepts and Methods, 1995 by A. Peres
Speakable and unspeakable in quantum mechanics, 1987 by J.S. Bell

General, advanced level e.g.,

Quantum Mechanics (3rd edition), 1998 by E. Merzbacher
Modern Quantum Mechanics (Revised edition), 1994 by J.J Sakurai.
Quantum Mechanics Vol I and II, 1961 by A. Messiah (Dover edition 1999).
The Principles of Quantum Mechanics, (4th edition) by P.A.M. Dirac
Quantum Mechanics (3rd edition), 1968 by L.I. Schiff

Specialized, others

Relativistic quantum mechanics, quantized fields
Quantum Field Theory, 2007, by Mark Srednicki
Atomic physics
The physics of atoms and molecules, (2nd edition) 2003 by B.H Bransden and C.J. Joachain.
Atomic Physics, 2005, by C.J. Foot.

If you would like to borrow a book briefly, come and see me as I may have a copy.

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