PHYSICS 3143: QUANTUM MECHANICS I (FALL 2011)

Schedule for QMI

Instructor: Brian Kennedy, N119 Howey (office hours: M 3-4 pm, or by appointment)
Assistant: Wenlong Yu, wenlong.yu@gatech.edu,(office hours: Physics library F 1-2 pm)
Lectures: TuTh 9.35-10.55 am L5

Goals

This is the first of a two semester sequence in quantum mechanics, a subject which is challenging from both a conceptual and mathematical point of view. In Phys 3143 we will build up the ideas and formalism of quantum theory, in particular the notions of linear superpositions of states, state preparation and measurement. We will employ an extended discussion of the classic Stern-Gerlach experiment as a vehicle for this purpose. This will prepare us naturally to discuss orbital and spin angular momenta and time evolution. We will then introduce wave mechanics, a topic you should have seen to some extent in sophomore modern physics, before treating the simple harmonic oscillator.

Provisional Syllabus

We may not stick rigidly to this syllabus, but the plan is as follows:

Brief historical review:
Quantum physics 1900-25.
The quantum state vector: analysis of Stern-Gerlach experiments
Introduction to probability amplitude, addition of probability amplitudes, basis states, quantum state vector, ket and bra vectors. State measurement and preparation. Calculation of expectation values and uncertainties in the analysis of Stern-Gerlach experiments.
Matrix mechanics:
Representing kets and bras with a basis. Freedom of basis and basis rotation: the rotation operator and the associated generator of rotations. Operators and their matrix representations. Change of representation. Photon polarization and spin.
Angular Momentum: spin and orbital
Generators of rotations as angular momentum operators. The angular momentum eigenvalue problem: raising and lowering operators. Spin 1/2 and spin 1 as important special cases. Uncertainty relations for angular momentum.
Time dependence in quantum mechanics:
The Hamiltonian operator and Schrodinger's equation. Examples of spins in a magnetic field and molecules in static and time-dependent electric fields.

Wave Mechanics in 1D:
Position operator, eigenstates and the wave function. Momentum operator in position basis. Momentum space. Free-particle and gaussian wave-packets. General properties of the solution of Schrodinger's equation. Particle in a box. Scattering in 1D.

Simple harmonic oscillator:
Ubiquity of harmonic motion. Raising and lowering operators: Dirac's algebraic operator approach to the eigenvalue problem for harmonic motion. Matrix and wave mechanics approaches. A discrete symmetry: inversion and the parity operator.

Grading

Homeworks 25 points
Class Tests (2) 30 points
Final 45 points

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 chapters 1-4 and 6-7 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 outset of the course. 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.

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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