Quantum Mechanics II

PHYS 712 Spring 2011

Text: My Notes, "Quantum Theory" (parts 1 & 2). The second set of notes will soon be available at the "Quick Copy" in the basement of the Russell House.

Tu-Th 11:00-12:15 SUM 333 (hopefully not for long)

Grading:

Homework	60%
Mid-term	20%
Project	20%

The "project" is on a subject of your own choosing. It should be less than a thesis and more than a homework problem. **Pick a topic of special interest to you**. The topic **must** have something to do with QM, *and should involve a calculation* or result of some kind. Please do not pick a subject you have already worked on – pick something new. The project will consist of a short paper (5-10 pages) and an oral presentation of about 20-30 min. Presentations will be made at the end of the semester. I will ask for a short description of your intended project in a couple of weeks (mostly to be sure you don't choose something too hard).

Here are topics presented in past years

3j and 6j symbols: an application
Action Principle in QM
Adiabatic Theorem
Aharanov-Bohm Effect
Aharanov-Casher Effect
Bohmian Mechanics
Bose-Einstein condensation
Carbon Nanotubes
Counterfactual Computation
Decay Constant of Vector Mesons
Deuteron: A Quick Look Into the Nucleon-Nucleon Interaction
Dirac's Theory of Electrons
Electron Gas in Intense magnetic field
Feynman Path Integral
Flux Quantization
Heavy Mesons
Hydrogen absorption spectrum
Kronig-Penny Model
Laser Cooling
Muon Capture by Atoms
Neutrino Oscillations
Nuclear Magnetic Resonance

Quantum Computers
Quantum Cryptography
Quantum Dots
Quantum Statistical Mechanics and Entanglement
Quantum Teleportation
Quantum Transport and the Kubo-Greenwood Formula
Quantum Tunneling Time

Tentative Schedule

Week Of	Subject	Objectives
1/10	The Hydrogen Atom	Understand the origin of the hyperfine interaction and calculate its effect using perturbation theory. The Runge-Lenz vector and O(4) symmetry. Relativistic effects treated as perturbations.
1/17	The Helium Atom	Variational calculation of the ground state of He. Use first-order PT to calculate the energies of ortho- and para-helium.
1/24	The Helium Atom	The exchange interaction as a consequence of the Pauli principle. Extension of the variational wavefunction to include electron correlation. The H- ion.
1/31	Electrons in a Periodic Potential	Understand the implications of translational symmetry and Bloch's theorem. Solve the Kronig-Penny model. Calculate band structure in the nearly-free electron and tight-binding approximations. Application to graphene.
2/7	Electrons in a Periodic Potential	Application to graphene
2/14	Neutrino Oscillations	Neutrino flavor and mass eigenstates: The solar neutrino puzzle. Atmospheric and solar neutrino oscillations.
2/21	The Density Matrix	Elements of the theory of measurment. Quantum Statistical mechanics
2/28	Scattering Theory	The scattering cross section. Continuum eigenstates of a local potential and the Lippmann-Schwinger equation. The optical theorem..
3/6	*********Spring Break**********	
3/14	Scattering Theory	Transition operator and its symmetries. Phase shift analysis
3/21	Second Quantization	Fock space and field operators. One-and two-particle operators.
3/28	Second Quantization	The non-interacting Fermi gas. Coulomb energy of the Fermi gas.
4/4	QM of Continuous Media	Quantization of waves on a string. Normal modes and Fock space operators. Quasi-particles. Noether's theorem.
4/11	Quantizing the EM Field	Maxwell's equations and the EM Lagrangian. Canonical quantization of the EM field. Photon operators. .
4/18	Quantizing the EM Field	Coupling the EM field to charged particles. Transition rates in hydrogen
4/25	Presentation of Projects	