

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
- Aharonov-Bohm Effect
- Aharonov-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 measurement. 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	