QUANTUM MECHANICS I - III

PHYS 516 - 518

Jan 1 - Dec. 31, 2010

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Course Schedule: MWF 11:00 - 11:50, Stratton 219

Objective: To provide the foundations for modern physics.

Two texts and one supplement will be used for this course. The first text has been chosen from among many admirable texts because it provides a more comprehensive treatment of quantum physics discovered since 1970 than other texts.

The second text will be used primarily during the second quarter of this course (PHYS517). It provides hands-on experience for solving binding and scattering problems in one dimension and potentials involving periodic potentials, again in one dimension.

The third text (optional) is strongly recommended for those who feel their undergratuate experience in this beautiful subject may be deficient in some way. It is out of print but a limited number of copies are often available through Amazon in the event out book store has sold out of their reprinted copies.

L. E. Ballentine
Quantum Mechanics
Englewood Cliffs, NJ: Prentice Hall, 1990 ISBN 0-13-747932-8

R. Gilmore
Elementary Quantum Mechanics in One Dimension
Baltimore, Johns Hopkins University Press, 2004 ISBN 0-8018-8015-7

R. H. Dicke and J. P. Wittke
Introduction to Quantum Mechanics
Reading, MA: Addison-Wesley, 1960 ISBN 0-?

Course Topics

- Schrödinger's Papers
    1. Quantization as an Eigenvalue Problem: Part I
    2. Quantization as an Eigenvalue Problem: Part II
    3. Quantization as an Eigenvalue Problem: Part III
    4. Quantization as an Eigenvalue Problem: Part IV
- Forms of Quantum Theory: Matrix Mechanics, Wave Mechanics, Path Integrals
- Separation of Variables:
    1. Klein-Gordan Equation
    2. Schrödinger Equation
- Frobenius's Method
- Eigenvalues and Eigenvectors
- Brief Remarks: Spherical Harmonics
- Time-Independent Perturbation Theory
- Applictions:
    1. Finite nuclear size
    2. Zeeman Effect
    3. Stark Effect
    4. Crossed Fields
- Harmonic Oscillator
    1. Analytic solution: Frobenius' Method
    2. Operator solution
    3. Discretization and Matrix Diagonalization
    4. Ginzburg-Landau Quartic Potential
- Coupled Oscillators
    1. Linear Molecules and Normal Modes
    2. One-Dimensional Solids

   (a) One atom/unit cell
   (b) Two atoms/unit cell
   (c) Three atoms/unit cell
3. Two-dimensional solids
4. Three-dimensional solids

- Electromagnetic Field
  1. Maxwell's Equations
  2. Vector and Scalar Potentials
  3. Normal Modes
  4. Independent Oscillators
  5. Quantization
- Time Dependence
- Time-dependent perturbation theory
- Representations:
  1. Schrödinger
  2. Interaction
  3. Heisenberg
- Applictions:
  1. Perturbed harmonic oscillator
  2. Fermi golden Rule
  3. Lorentzians
- Angular Momentum
  1. Analytic representation, angular variables: L
  2. Algebraic representation, $|l, m_l\rangle$
  3. $J \simeq a^\dagger a$
  4. Spin angular momentum: S
  5. Total angular momentum: J
  6. Spherical harmonics
  7. Clebsch-Gordan coefficients
- Angular Momentum Applications
  1. Shielded Coulomb Potential → Mendelyeev
  2. Harmonic + Square Well + Spin Orbit = Nuclear Shell Model
  3. Hydrogen → Positronium → Charmonium → Bottomonium