Physics 195ab
Course Notes
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(fcp/tex/ph125/ay0102/outline)

1 Introduction

This note describes the Ph 195 course, "Advanced Quantum Mechanics" and gives some administrative information.

There is a web page for the course:
http://www.cithep.caltech.edu/ fcp/ph195/index.html
All course materials will be posted to this web page.

Quantum Mechanics is at the foundation of modern physics; a thorough understanding is important for a practicing physicist. This is a serious course, designed to go deeper into the concepts and techniques than the more standard course. It is a 12 unit course, reflecting the greater intensity. The outline (below) of material to be covered is ambitious for two quarters. I intend to remain flexible concerning both pace and subject concentration.

I hope to keep classes somewhat informal, and encourage discussion among participants. My notion is that the notes will provide the backbone, the classes will aid understanding, and the homework will provide depth and practical experience. In particular, I would like to use the classes to address questions which arise both in the reading and on the homework, and to provide illustrative examples relevant to the discussions in the notes.

2 Course Outline

Here follows a course outline. We may change it midstream according to the interests and background of the course participants. There will (more-or-less) be a course note handout corresponding to each major topic heading in the outline.

1. Introduction
   (a) Units
   (b) Bohr atom
   (c) Basic principles

2. Ideas of Quantum Mechanics
    (a) Probability amplitudes, Wave equations, and Dispersion relations.
    (b) Hilbert spaces, Self-adjoint operators
    (c) Postulates of quantum mechanics
    (d) Uncertainty Principle
3. Path Integral Approach
    (a) Hamiltonian for a charged particle in an electromagnetic field
    (b) Ahronov-Bohm effect
4. Density Matrix Formalism
    (a) Statistical ensembles
    (b) Postulates of quantum mechanics
    (c) Entropy
    (d) Canonical ensemble
5. Two state system – $K^0\bar{K}^0$ mixing
    (a) Dealing with non-mass eigenstates
    (b) Dealing with decaying particles
6. Harmonic Oscillator in one dimension
    (a) Annihilation and Creation operators
    (b) Hermite polynomials
7. Resolvents and Green's Functions
8. Angular Momentum
    (a) SU(2), spin-1/2
    (b) Addition of Angular Momenta
    (c) Wigner-Eckart Theorem
    (d) Angular distributions from rotational invariance

(e) Breaking of rotational symmetry

9. Solving the Schrödinger equation, approximately
   (a) Variational method
   (b) WKB approximation
   (c) Time-independent perturbation theory
   (d) Time-dependent perturbation theory
10. Scattering
   (a) Fermi's golden rule
   (b) Partial wave expansion
   (c) Resonances
11. Identical particles
   (a) Bosons
   (b) Fermions, Pauli exclusion principle
12. Second Quantization (photon field)
13. Relativistic Invariance, the Dirac Equation