PHYS-773: Quantum Mechanics II Syllabus

1. General information

Class time & location:

SDSMT: Mon, Wed 11:30AM - 12:50PM, Classroom Building, Room 108
SDSU: Mon, Wed 12:30PM - 01:50PM, Pugsley Continuing Ed Cen, Room 0214
USD: Mon, Wed 12:30PM - 01:50PM, Patterson Hall, Room 225

Instructors:
Dr. Andre Petukhov, Andre.Petukhov@sdsmt.edu , (605) 394-2364 (o)
Dr. Xinhua Bai, Xinhua.Bai@sdsmt.edu , (605) 394-5198 (o), (302) 593- 6517 (c)

Textbook:
"Quantum Mechanics", by Eugen Merzbacher, John Wiley, 3rd edition

Reference books:
"Quantum Mechanics (Nonrelativistic Theory)", by L. D. Landau and E. M. Lifshitz
"Quantum Mechanics", Third Edition, by Leonard I. Schiff, McGraw-Hill (1968)
"The Principle of Quantum Mechanics", by P. A. M. Dirac, Clarendon Press, 4th edition.

2. Students Involvement

As a high level graduate course, this course requires active and consistent involvement from students. Each student is required to give one 60-min lecture (preferably in pdf format from LaTeX source, lecture templates are posted) on the scheduled course contents (see **Sections 4 and 5** below) during the semester.

All students need to pickup their lecture topics before the end of the second week of the class or earlier. Along with lecture the students have to provide (but not present) solutions of two relevant problems of their own choice as a supplementary material. Students will be required to grade presentations of their peers and email their feedback/grades to the instructors: xinhua.bai2011@gmail.com

Students are encouraged to work on their lectures in small groups, especially when they choose to cover the contents in the same chapter.

3. Grading policy and structure

The overall breakdown of grading for this course is:

Class participation:	Required for credits [requires pre-approval from instructor(s) for absence]
Student lecture:	40%
Midterm Exam:	25%
Final exam:	35%

The final course letter grade will be derived from the overall score following the following scale:

A > 90 %
B 90% - 80 %
C 80% - 70%
D 70% - 60%
F <60%, or missing the required lecture.

4. Tentative class schedule (may change during the semester)

Weeks 1 and 2:
Syllabus: policies & schedule.
Vector Spaces and Matrix Mechanics (Chapters 8 (p. 135), 9 (p. 179), 10 (p. 207))
1. Probability Amplitudes and Their Composition
2. Vectors and Inner Products, Bra-Ket Notations
3. Matrix representation of the operators
4. Hilbert Space, Representation Theory
5. Coordinate and Momentum Representations
6. Variational Formulation of the Eigenvalue Problem
7. Commuting Observables and Simultaneous Measurements 214
8. The Heisenberg Uncertainty Relations 217
9. Algebraic Theory of the Harmonic Oscillator 220*

Week 3 and 4:
The Spin and the Total Angular Momentum (Chapters 16 (p. 372), 17(p. 410))
1. Angular Momentum and Rotations
2. Algebraic Theory of the Angular Momentum
3. Stern-Gerlach Experimet, Intrinsic Angular Momentum, Polarization of Waves
2. The Quantum Mechanical Description of the Spin, Pauli Matrices
4. Quantum Dynamics of a Spin System*
6. Density Matrix and Spin Polarization
7. Addition of Angular Momenta*
8. Wigner-Eckart Theorem and its applications*

Week 5:
Atoms and Molecules
1. One-Electron Atoms
2. The Pauli Principle
3. The Periodic Table
4. The Slater Determinant

Week 6 & 7:
CHAPTER 18 Bound-State Perturbation Theory and Variational Method 451
1. The Perturbation Method 451
2. Inhomogeneous Linear Equations 453
3. Solution of the Perturbation Equations 455

4. Quadratic Stark Effect, Electrostatic Polarization and the Dipole Moment 459*
5. Degenerate Perturbation Theory, Linear Stark Effect 463*
6. Degenerate Perturbation Theory, Zeeman Effect*
7. Variational Method, The Helium Atom*
6. Variational Method, The Hydorgen Molecule*

Midterm Exam

SPRING BREAK

Week 8:
CHAPTER 19 Time-Dependent Perturbation Theory 482
1. The Equation of Motion in the Interaction Picture 482
2. The Perturbation Method 485
3. The Hartree-Fock Method (Chapter 22, p560)*
4. Coulomb Excitation and Sum Rules 487 *
5. The Atom in a Radiation Field 491*
6. The Absorption Cross Section 495 *
7. The Photoelectric Effect 501
8. The Golden Rule for Constant Transition Rates (optional) 503

Week 9:
CHAPTER 14 The Principles of Quantum Dynamics 315
1. The Evolution of Probability Amplitudes and the Time Development Operator 315
2. The Pictures of Quantum Dynamics 319
3. The Quantization Postulates, Canonical Quantization 323*
5. Canonical Quantization in the Heisenberg Picture (optional) 331

Week 10:
CHAPTER 21 Identical Particles 535
1. The Indistinguishability of and the State Vector Space for Identical Particles 535
2. Creation and Annihilation Operators 538
3. The Algebra of Creation and Annihilation Operators 540
4. Dynamical Variables 544
5. The Continuous One-Particle Spectrum and Quantum Field Operators 546
6. Quantum Dynamics of Identical Particles 549

Week 11:
CHAPTER 22 Applications to Many-Body Systems 555
1. Angular Momentum of a System of Identical Particles 555
2. Angular Momentum and Spin One-Half Boson Operators 556
3. First-Order Perturbation Theory in Many-Body Systems 558
4. Quantum Statistics and Thermodynamics 564

Week 12:
CHAPTER 23 Photons and the Electromagnetic Field 569
1. Fundamental Notions 569

2. Energy, Momentum, and Angular Momentum of the Radiation Field 573*
3. Interaction with Charged Particles 576
4. Elements of Quantum Optics 580
5. Coherence, Interference, and Statistical Properties of the Field 583

Week 13:
CHAPTER 24 Relativistic Electron Theory 592
1. The Electron-Positron Field 592
2. The Dirac Equation 596
3. Relativistic Invariance 600
4. Solutions of the Free Field Dirac Equation 606*
5. Charge Conjugation, Time Reversal, and the PCT Theorem 608
6. The One-Particle Approximation (optional) 613
7. Dirac Theory in the Heisenberg picture (optional) 617
8. Dirac Theory in the Schrodinger Picture and the Nonrelativistic Limit (optional) 621

Week 14: Review/discussion, Qs&As, and exercises

Week 15: Final exam

5. Topics and tentative schedule of student lectures (may change during the semester)

1) Algebraic Theory of the Harmonic Oscillator
   February 6, James Rhodes
2) Quantum Dynamics of a Spin System
   February 13, Jacob Boschee
3) Addition of Angular Momenta
   February 15, Allen R Goodman
4) Wigner-Eckart Theorem and its Applications
   February 27, Xiaoyi Yang
5) Quadratic Stark Effect, Electrostatic Polarization and the Dipole Moment
   February 29, Md Amimul Ehsan
6) Degenerate Perturbation Theory, Linear Stark Effect
   March 12, Chris Chiller
7) Degenerate Perturbation Theory, Zeeman Effect
   March 14, Angela Alanson Chiller
8) Variational Method, The Helium Atom
   March 19, Dana Byram
9) Variational Method, The Hydorgen Molecule
   March 21, Noha Alzahrani
10) The Hartree-Fock Method
   March 26, Andrew W. Whitley
11) Coulomb Excitation and Sum Rules
   March 28, Ben Jasinski
12) The Atom in a Radiation Field
   April 02, Douglas Tiedt

13) The Absorption Cross Section
April 04, Jan Shillander
14) The Quantization Postulates, Canonical Quantization
April 11, DAnn Barker
15) Energy, Momentum, and Angular Momentum of the Radiation Field
April 16, Donald Hixon
16) Solutions of the Free Field Dirac Equation
April 18, Daniel Rederth