Physics 424: Quantum Mechanics II
Lehigh University, Fall 2024

Instructor: Ariel Sommer
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Class: MW 3:00 – 4:15 pm, Lewis 514

In this course, you will learn how to apply several widely used approximation methods in quantum mechanics and to describe the scattering of quantum particles. The material in this course has applications in most areas of physics, especially atomic, molecular, solid-state, nuclear, particle, and laser physics.

Textbook:
Sakurai and Napolitano, *Modern Quantum Mechanics*, 3rd ed., Cambridge, 2021

Recommended additional text:
N. Zettili, *Quantum Mechanics: Concepts and Applications* (2nd ed. 2009 or 3rd ed. 2022)

Further reference:
L. Ballentine, *Quantum mechanics: a modern development,* World Scientific 2015
Available as free e-book from the Lehigh library (link)

Main topics:
Time-independent perturbation theory
Applications to atomic structure
Time-dependent perturbation theory
Scattering theory

Grading:
Final grades will be based on homework, midterms, and a final exam. The weights will be approximately:

Homework	40%
Midterms	30%
Final	30%

Homework: Homework will be assigned weekly or every other week. You are expected to turn in homework on time. You may work together on the homework, but make sure that you are able to complete the problems on your own. The work you turn in must be your own.

Late homework: Please contact me if you would like to request an extension due to illness or other circumstances.

Learning Outcomes: After successfully completing the course, students should be able to:

A. Apply the course material in a direct way to solve problems. Examples include the following.
    1. Time-independent perturbation theory (TIPT)

    a. Understand the formalism of TIPT
    b. Apply TIPT to calculate energy shifts and perturbed eigenstates in idealized models (harmonic oscillator, square well, Coulomb potential)
    c. Calculate the energy splittings in a hydrogen atom due to the Stark effect, Zeeman effect, and relativistic corrections
    d. Apply the variational method to find approximate ground states
2. Time-dependent perturbation theory (TDPT):
    a. Predict approximate time-evolution of quantum states and transition probabilities
    b. Predict time-evolution of observables
    c. Apply Fermi's Golden Rule to predict transition rates into a continuum
    d. Understand the selection rules in dipole transitions of a hydrogen atom
    e. Apply the adiabatic and sudden approximations
3. Scattering theory:
    a. Understand the formalism of quantum scattering
    b. Calculate scattering amplitudes and cross sections in non-relativistic collisions
    c. Find partial-wave phase shifts for spherically symmetric potentials

B. Demonstrate conceptual understanding of the course material. Examples:
    1. Determine the conditions of validity for a given method
    2. Analyze limiting cases to check the validity of a solution
    3. Creatively apply the course material to unfamiliar problems
    4. Explore the physical implications of a solution to a problem

Accommodations for Students with Disabilities: If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, Williams Hall, Suite 301 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community: Lehigh University endorses The Principles of Our Equitable Community [http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.