Syllabus, PHYS 784, Quantum Mechanics II, Spring 2021

Time: Tuesday, 4:30-7:10pm
Place: Online, Blackboard Collaborate Ultra (BBCU)
Instructor: Erhai Zhao
Office Hour: by appointment
Email: ezhao2@gmu.edu

How to reach me: Email is preferred during distance learning. I will try to respond within 24 hours.

Textbook
For the sake of continuity, I will stick to the book used in Quantum Mechanics I (Phys 684),
Modern Quantum Mechanics, 2nd, J. J. Sakurai and J. J. Napolitano
You can also use the 3rd Edition, which just came out (I have not checked it out yet).

I will follow the book *loosely* and cover *chapter 5 to 7*. Materials from other sources will also be used throughout. I will skip chapter 8 on Dirac equation: if you are interested, I strongly encourage you to take Phys 786, Quantum Field Theory, where Dirac equation is discussed in modern perspective as a field equation.

Grades
Homework (60%) + Final Exam (40%).

Lectures
Please log in Blackboard (BB) and join the virtual BBCU classroom at the designated class time. I will use OneNote and screen sharing to deliver the lecture. The lectures will be recorded. Since the class size is small, please feel free to unmute yourself or use the chat box to ask questions during the lecture.

I will not post lecture notes.

Homework
There will be 6 sets of homework assignments. They will appear in the Assignment folder of Blackboard with due date indicated. To submit your homework, upload your answer in one single pdf file to BB. Bloated, compressed, or multiple image (jpg, tiff, png…) files will be returned. In case of BB technical difficulties, email the file to me directly.

The homework will be graded on a coarse scale: Excellent (5), Very Good (4), Fair (3), Absent (0).

Exam
The final exam will be take-home, open-book, and open-notes. It will be assigned and collected via BB similar to the homework.

Prerequisite
This course continues from Phys 684, Quantum Mechanics I (chapter 1 to 4 of Sakurai).

Course Goals
Most real-world problems in Quantum Mechanics cannot be solved exactly. So the main goal of this course is to develop a repertoire of approximation techniques. Each approximation method will be illustrated by working out examples in detail.

The secondary goal is to develop the basic concepts and techniques (known as "second quantization" which is more or less a misnomer) to treat quantum many-body systems — the world has many particles and they interact!

Topics (colored topics will be discussion if time permits)

1. Semiclassical expansion: WKB, bound states and Bohr-Sommerfeld quantization rule, tunneling, examples.

2. Time-independent perturbation theory: 1st and 2nd order, level repulsion, projection operators, lift of degeneracy. Examples: perturbed harmonic oscillator, Stark effect, fine structure of H atom.

3. Time-dependent perturbation theory: interaction picture, Dyson series, constant and harmonic perturbation, transition rate and Fermi's golden rule, photoelectric effect.

4. Scattering theory: S and T matrix, Lippmann-Schwinger Eq, Green function, cross section, Born approximation, partial waves, phase shifts, scattering length, resonance and bound states.

5. Identical particles and interactions: second quantization, exchange interaction, Helium atom and variational methods, interacting Fermi gas, BCS theory of superconductivity.

6. Light-matter interaction: quantization of electromagnetic field, photon states, cavity QED as open quantum system, superconducting circuits.

University Resources
Learning Services (https://learningservices.gmu.edu/)
Student Support and Advocacy Center (https://ssac.gmu.edu/)
Counseling and Psychological Services (https://caps.gmu.edu/)
Mason's Title IX Coordinator (703-993-8730, titleix@gmu.edu)

Academic Integrity
The George Mason University Honor Code can be found at the Office of Academic Integrity website http://oai.gmu.edu. It has clear guidelines regarding cheating, plagiarism, and other academic misconduct.

Accommodations
Disability Services at George Mason University is committed to providing equitable access to learning opportunities for all students by upholding the laws that ensure equal treatment of people with disabilities. If you are seeking accommodations for this class, please first visit http://ds.gmu.edu/ for detailed information about the Disability Services registration process. Then please discuss your approved accommodations with me. Disability Services is located in Student Union Building I (SUB I), Suite 2500. Email:ods@gmu.edu — Phone: (703) 993-2474.

Diversity and Inclusion
Please refer to Mason's Non-Discrimination Policy,
https://universitypolicy.gmu.edu/policies/non-discrimination-policy/.
and the Mason Diversity Statement,
https://stearnscenter.gmu.edu/knowledge-center/general-teaching-resources/mason-diversity-statement/.

Course Materials and Student Privacy
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