Phys. 671 Spring 2020 Instructor: Xerxes Tata

This class is the second semester of a two-semester course in non-relativistic QM (follows PHYS 670). Please review the free particle solution in spherical polar coordinates as this is important for scattering theory (p 346-350 of Shankar). We talked about this a the end of the last term and you will soon get HW asking you to write the plane wave in spherical coordinates. As I had told you last term, I will assume all of you have solved the Hydtogen atom and are familiar with its solutions from baby QM classes.

We will take up where we had left off last term, going quickly through Chap. 14 on spin – some of this you already have familiarity with. We will then move on to the chapter on combining angular momenta (Shankar, Chap. 15). During the course we will emphasize the applications of QM to complex systems using approximation methods because the dynamics of these systems cannot be solved exactly. I urge you to supplement our text with other excellent texts of your choosing. These include: Sakurai, Merzbacher, Schiff, Bethe and Jackiw (especially for Hartee Fock methods) Landau and Lifschitz, Davydov, Messiah, Baym, Dirac, Weinberg and Gottfried and Yan, to name a few.

Topics to be covered:

- Intrinsic angular momentum of particles (spin)
- Addition of angular momenta
- Energy degeneracies of 3-D Coulomb and harmonic oscillator potentials
- Approximation Methods (WKBJ, perturbation theory, variational methods) and their applications to real systems.
- Time-dependent Hamiltonians using perturbation theory
- Aharanov-Bohm effect, Berry's phase
- Elements of elastic scattering theory
- Self-consistent fields and Hartree-Fock methods
- Relativistic wave equations and failure of relativistic quantum mechanics for one-particle systems
- Quantizing the electromagnetic field
- Decay rates for atomic transitions
- Einstein-Podolsky-Rosen type correlations

While we will definitely cover the core topics in non-relativistic QM (through scattering theory), and depending on time and interest, we will pick and choose from the other topics.

HW will be assigned regularly (roughly weekly), and will count for 1/3 of your grade. Also, we will have one midterm and a final exam, each counting for a third of your grade. We will decide the format for these exams when the time approaches.

The class will provide you expertise to work on problems for which non-relativistic quantum mechanics provides an adequate framework, and prepare you for courses in Quantum Field Theory, which is the framework used by research physicists working with quantum systems in which relativistic effects are important.