Phys 3765 Quantum Field Theory I, 2025

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Practical Information:

class meetings: Tuesday and Thursday 11:00-12:15, 103 Allen Hall

office hours: Tuesday and Thursday 12:15-1:00. .Feel free to email me to set up individual meetings if you want.

grading policy: the final grade will be determined from approximately 8 assignments will be given during the term. There will be no final exam.

primary course text:. Peskin and Schroeder. Other useful books are Srednicki and Donoghue, Golowich, and Holstein.

Course Description:
This course introduces the concepts of relativistic quantum field theory with a focus on a complete description of scalar field theory.

Course Objectives:
Upon completion of the course the student will be able to perform computations in relativistic field theory with Feynman rules and functional methods, including deriving quantum corrections to physical processes and their renormalization.

Course Content:

1. Historical Introduction [Umezawa, Weinberg, Schweber]
   ladder operators, Dreimaennerarbiet, Jordan's quantum mechanics, Dirac, Fermi, early struggles with gauge invariance, early struggle with renormalization
2. Atoms and Photons [Sakurai, chapters 1 and 2]
   quantum mechanics, gauge invariance in quantum mechanics, field expansion, classical limit, Fermi's Golden Rule and atomic transitions, spontaneous emission, black body radiation, scattering theory, Rayleigh scattering, Thomson scattering, a first look at renormalization & the Lamb shift a la Bethe
3. Classical Relativistic Fields [P&S]
   units, tensors, Lorentz transformations, scalar fields, equations of motion, Noether's theorem, energy-momentum tensor, angular momentum tensor
4. Quantum Relativistic Fields [P&S]
   Klein-Gordon theory, field quantization, field operators, causality, complex KG theory, conserved currents, propagators
5. Scattering Theory [P&S]
   Schroedinger and Heisenberg pictures, scattering picture, time ordering, adiabatic switching (and its failure). Gell-Man--Low theorem, S-matrix. bubble diagrams, disconnected diagrams, leg corrections, cross sections, T-matrix, scattering amplitude, phase space
6. Field Manipulations [P&S]
   operators contractions, Wick's theorem, Feynman rules, symmetry factors, diagrams in momentum space, Mandelstam variables
7. Renormalization [P&S]
   {2d delta function scattering [Jackiw], field strength renormalization, Kallen representation, LSZ theorem, optical theorem, particle widths, BPH renormalization, Wilsonian renormalization, counterms, one loop structure of ϕ^4 theory, renormalization group, running coupling, anomalous dimension, solving RG equations.
8. Functional Methods [P&S]
   functional derivatives, the Schroedinger functional, the path integral, subtleties with the path integral, Legendre transformation, generating functional, Schwinger-Dyson equations.
9. Introduction to the Standard Model [P&S]
   QED, QCD, the weak sector, the Higgs mechanism

Academic Integrity:

Students in this course will be expected to comply with the University of Pittsburgh's Policy on Academic Integrity. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process, initiated at the instructor level, as outlined in the University Guidelines on Academic Integrity. This may include, but is not limited to, the confiscation of the examination of any individual suspected of violating University Policy. Furthermore, no student may bring any unauthorized materials to an exam, including dictionaries and programmable calculators.

Disability Statement:

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 216 William Pitt Union, (412) 648-7890/ (412) 383-7355 (TTY), as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course. A comprehensive description of the services of that office can be obtained at www.drs.pitt.edu.