THE UNIVERSITY OF ARIZONA

PHYS 579B – Advanced Relativistic Quantum Mechanics II (QFT II)

Fall 2019

Tuesday and Thursday 3:30 - 4:45 PM, PAS 314

Class dates: August 27 – December 10 (no class on November 28)

Instructor and Contact Information

Course web page	https://d2l.arizona.edu/d2l/home/819159
Instructor	Professor Stefan Meinel
Office	Department of Physics, PAS 420A
Office hours	Wednesday, 2:00 - 4:00 PM. You are also welcome to stop by at other times, but to make sure I'm available it is best to make an appointment.
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Phone	520 621 2453

Course Description

This course covers advanced topics in quantum field theory, the framework that underlies much of modern physics. We will derive the path-integral formalism for bosonic and fermionic fields from the canonical formalism. Regularization and renormalization will be discussed, both in general terms and for specific field theories. We will apply the path-integral formalism to QED and to non-Abelian gauge theories such as QCD, and use it to derive their Feynman rules. Selected one-loop calculations with dimensional regularization will be performed. Time permitting, we will also introduce the Higgs mechanism and the electroweak sector of the Standard Model.

Learning Outcomes

Here are some examples of what students should be able to do after taking this course:

- Perform manipulations with path integrals, including integrals over Grassmann variables
- Derive Ward identities associated with a symmetry
- Derive Feynman rules using path-integral quantization
- Evaluate the degree of divergence of a Feynman diagram
- Assess the renormalizability of a quantum field theory with a given Lagrangian
- Carry out one-loop calculations in scalar field theory and in QED using dimensional regularization
- Explain the Fadeev-Popov procedure for non-Abelian gauge theories

Course Prerequisites

The prerequisite for this course is PHYS 579A (Advanced Relativistic Quantum Mechanics I). The topics covered in PHYS 579A are similar to those in David Tong's Quantum Field Theory lecture notes, which are available at http://www.damtp.cam.ac.uk/user/tong/qft.html.

Lecture Notes

I plan to provide typeset lecture notes on the D2L course web page; I will update these notes frequently. The lecture notes are not meant to replace the use of textbooks; it is strongly recommended that you read additional material on your own.

Recommended Textbooks

The following textbooks may be useful. Please be careful with different conventions used in the different books. For example, Weinberg uses the $(-,+,+,+)$ metric, while most other books use the $(+,-,-,-)$ metric.

- Michael E. Peskin and Daniel V. Schroeder, *An Introduction To Quantum Field Theory* (Westview Press). This book is available as a free e-book at http://ezproxy.library.arizona.edu/login?url=https://doi.org/10.1201/9780429503559. Corrections are available at https://www.slac.stanford.edu/~mpeskin/QFT.html.
- Matthew D. Schwartz, *Quantum Field Theory and the Standard Model* (Cambridge University Press). Corrections are available at https://schwartzqft.fas.harvard.edu/corrections.
- Steven Weinberg, *The Quantum Theory of Fields, Volume I: Foundations* (Cambridge University Press). This book is available as a free e-book at http://ezproxy.library.arizona.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=570474&site=ehost-live&ebv=EB&ppid=pp_C1.
- Steven Weinberg, *The Quantum Theory of Fields, Volume II: Modern Applications* (Cambridge University Press). This book is available as a free e-book at http://ezproxy.library.arizona.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=570477&site=ehost-live&ebv=EB&ppid=pp_C1.
- Lewis H. Ryder, *Quantum Field Theory* (Cambridge University Press; 2nd edition).
- John C. Collins, *Renormalization* (Cambridge University Press).
- Jean-Bernard Zuber and Claude Itzykson, *Quantum Field Theory* (Dover Books on Physics).

Homework

The homework problems will be posted on the D2L course web page together with their due dates. You are encouraged to discuss the problems with other students, but the write-up of the solutions must be your own and represent your own understanding.

Please write legibly. I strongly encourage you to typeset your answers, for example using LaTeX.

Exams

There will be two in-class written exams:

- Midterm exam: Thursday, October 24, 3:30 - 4:45 PM.
- Final exam: Wednesday, December, 18, 3:30 - 5:30 PM.

You may bring up to two letter-size pages with formulas/notes (i.e., one two-sided sheet or two one-sided sheets). Non-standard integrals will be provided if needed.

Grading Scale and Policies

Your overall course percentage will be calculated according to the following weighting scheme:

- Homework problems: 60%
- Midterm exam: 15%
- Final exam: 25%

Based on your overall percentage x, you will receive *at least* the following letter grades:

- $85\% \leq x$: A
- $70\% \leq x < 85\%$: B
- $55\% \leq x < 70\%$: C
- $40\% \leq x < 55\%$: D
- $x < 40\%$: E

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at http://catalog.arizona.edu/policy/grades-and-grading-system#incomplete and http://catalog.arizona.edu/policy/grades-and-grading-system#Withdrawal.

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu/) to establish reasonable accommodations.

University Policies

The university policies are available at https://academicaffairs.arizona.edu/syllabus-policies.

Subject to Change Notice

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.