08.128.809 Theoretische Elementarteilchenphysik
Quantum Field Theory II

Instructor: Felix Yu (yu001@uni-mainz.de)

- **This lecture course is mainly designed as an independent study course.**
- Lectures: Lecture videos (recorded from SoSe 2020) will be available every week on Panopto (video.uni-mainz.de), which will be integrated into Moodle (lms.uni-mainz.de). Students are expected to watch the appropriate lectures for each week and then participate in a weekly office hours over Zoom, Thursdays from 10-12 pm (c.t.).
- Discussion sessions: In addition, there will be supervised homework discussion sessions approximately every two weeks over Zoom, on Fridays, 8-10 am (c.t.), where students will be asked to present their homework solutions to everyone else.
- Homework: due at the beginning of each discussion session by e-mail (photo or scan) to yu001@uni-mainz.de
- Exam: Oral exams on request. Oral exams are expected to be administered via video conference.
- Exam requirement: 50% of homework credits

Main topics

Renormalization The need for renormalization in interacting theories; Lehmann-Symanzik-Zimmermann reduction formula; Källén-Lehmann spectral density function; ultraviolet and infrared divergences; counting divergences and operator renormalizability; general features of wavefunction renormalization and vertex renormalization; Callan-Symanzik equation

Functional integrals Path integral approach to scalar field theory and fermion field theory; variational method for deriving Feynman rules

Representation theory Review of group theory; Lie algebras

Non-Abelian gauge theory Pure Yang-Mills theory; quantization of Yang-Mills fields; Fedeev-Popov ghosts; renormalization of Yang-Mills at 1-loop; Quantum Chromodynamics; renormalization of QCD; asymptotic freedom; quark/hadron phenomenology and basic jet physics; (time-permitting, BRST symmetry)

Spontaneous symmetry breaking Goldstone theorem; chiral symmetry; spontaneous symmetry breaking via chiral condensate; spontaneous symmetry breaking via Higgs field; Standard Model electroweak theory; quantization of massive, non-Abelian gauge bosons; R_ξ gauge fixing; Goldstone boson equivalence

Miscellaneous topics Optical theorem; gauge hierarchy problem

References

Michael Peskin, Daniel Schroeder An Introduction to Quantum Field Theory, Westview Press, 1995, ISBN 0-201-50397-2

Matthew D. Schwartz Quantum Field Theory and the Standard Model, Cambridge University Press, 2013, ISBN 1107034736

Lecture notes The lecture notes and videos will be uploaded to Moodle. Additional arXiv or supplementary textbook references for specific topics will be given upon request.

Tentative Schedule

April 15, 2021 Office hours (Lec. 1, 2)

April 22, 2021 Office hours (Lec. 3)

April 23, 2021 Discussion session 1. Homework 1 due.

April 29, 2021 Office hours (Lec. 4, 5)

May 6, 2021 Office hours (Lec. 6)

May 7, 2021 Discussion session 2.

May 13, 2021 Holiday

May 14, 2021 Make-up Office hours (Lec. 7, 8)

May 20, 2021 Office hours (Lec. 9)

May 21, 2021 Discussion session 3.

May 27, 2021 Live: Lecture 10

June 3, 2021 Holiday.

June 4, 2021 Discussion session 4

June 10, 2021 Office hours (Lec. 11, 12)

June 17, 2021 Office hours (Lec. 13)

June 18, 2021 Discussion session 5.

June 24, 2021 Office hours (Lec. 14, 15)

July 1, 2021 Office hours (Lec. 16)

July 2, 2021 Discussion session 6.

July 8, 2021 Office hours (Lec. 17)

July 15, 2021 Office hours (Lec. 18)

July 16, 2021 Discussion session 7.