

Handout

Prerequisites: Thorough understanding of all course lectures, in particular second quantisation; “Einführung in die Quantenfeldtheorie” (SS 2005, Prof. Lenz), in particular path integrals; phenomenology of the standard model on the level of “Kern- und Teilchenphysik (Experimentalphysik VI)”.

Location and Time: _____ Lecture, _____ Tutorial.

Language: Like practically all literature, the lecture will be in English. Questions and comments in English or German encouraged.

Goals: Introduction into non-Abelian gauge theories and the principles of modern elementary particle physics.

1. Review of Quantum Field Theory
2. Classical and Quantised Gauge Theories
geometric interpretation of non-Abelian gauge theories – Faddeev-Popov quantisation
3. Concepts in Regularisation and Renormalisation
dimensional regularisation – renormalisation group equations – running coupling
4. Symmetries and their Quantum Realisations
theorems on symmetries – Goldstone and Higgs-Kibble realisation – anomalies
5. Further Topics
as time permits

Concept: “Commenting Lecture”, i.e. central points developed in lecture, accompanied by textbook studies. Specific references for preparation of each hour and further reading can be found on the web-page below.

Estimated time for preparation and further studies, including tutorial: ca. 6 SWS.

Tutorials: 1 SWS. Active participation a must for success. Examples are distributed in the lecture and discussed in the next tutorial.

Website for references, up-to-date information and pdf-files of examples:

http://theorie3.physik.uni-erlangen.de/lectures/ws2005_2006/griesshammer/QFTII.html

Surgical (office) hours: You are always welcome with questions, discussions, comments and critique, in particular Monday afternoon between 13 and 16 hrs in my office: 02.701, phone 852-8475, Email hgrie@theorie3.physik.uni-erlangen.de or hgrie@ph.tum.de [sic!].

Notation and Conventions: Like most textbooks, we follow Bjorken and Drell in the conventions and in using the “natural system of units” $\hbar = c = 1$, together with the “rationalised Heaviside-Lorentz system” of electro-magnetic units – also for non-Abelian gauge theories.

Einstein sum convention for two repeated indices, except when specified otherwise.

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|-------------------------------------|---|
| “east-coast metric” | $g_{\mu\nu} = \text{diag}(1, -1, -1, -1)$ |
| contravariant 4-vectors | $V^\mu = (V^0, \vec{V})$ |
| space-time indices | $\mu, \nu, \rho, \dots = 0, \dots, 3$ |
| spatial indices | $i, j, k, \dots = 1, 2, 3$ |
| spinor indices | $\alpha, \beta, \gamma \dots = 1, \dots, 4$ |
| internal indices (e.g. gauge group) | a, b, c, \dots |

please turn over

Some Books:

The “books to the lecture”:

- [1] A. Zee: Quantum Field Theory in a Nutshell; Princeton University Press, 50€. Brilliant but dangerous: is addictive, and avoids calculations for good arguments. Tell me how you like it.
- [2] Michael E. Peskin and Daniel V. Schroeder: An Introduction to Quantum Field Theory; Addison Wesley, 77€.
- [3] Lewis H. Ryder: Quantum Field Theory, 2nd ed.; Cambridge University Press, 55€.
- [4] Michio Kaku: Quantum Field Theory; Oxford University Press, 55€.
- [5] Pierre Ramond: Field Theory: A Modern Primer, 2nd ed.; Addison Wesley, 55€.

Classics and Modern Classics:

- [6] Steven Weinberg: The Quantum Theory of Fields, Vol. 1 and Vol. 2; Cambridge University Press, 65€ each.
- [7] James D. Bjorken and Sidney D. Drell: Relativistic Quantum Mechanics; McGraw Hill, 55€. Also in German.
- [8] James D. Bjorken and Sidney D. Drell: Relativistic Quantum Fields; McGraw-Hill, 55€. Also in German.
- [9] Claude Itzykson and Jean-Bernard Zuber: Quantum Field Theory; McGraw-Hill, 70€.

“The price is right”:

- [10] Waren Siegel: Fields; <http://insti.physics.sunysb.edu/siegel/plan.html>, free.

Only in German:

- [11] Taichiro Kugo: Eichtheorie; Springer, 60€.

More applied to high-energy Physics:

- [12] Ta-Pei Cheng and Ling-Fong Li: Gauge Theory of Elementary Particle Physics; Oxford University Press, 95€.
- [13] Taizo Muta: Foundations of Quantum Chromodynamics: An Introduction to Perturbative Methods in Gauge Theories; World Scientific Lectures Notes in Physics, 95€.