Course content of the course *Modern Theoretical Physics* in 2017

Lectures: 2 hours each week: 215, Thursday 14^{00} to 16^{00}
and 2 hours for discussions: 312, Monday 09^{00} to 11^{00}

09/11 Special Relativity Repetition: Invariants, Lorentztransformations, Poincaré group [1, 2, 3]
Introduction to Special Relativity and the Poincaré algebra

09/14 Special Relativity: Spinors [2, 3, 4]
differential operators implementing the group structure of translations and rotations; spinors as representations of the rotation group; discussion of the group structure of the Poincaré algebra

09/21 Quantum Field Theory: Approaches: canonical, path-integral [3, 5, 6, 7, 13]
explaining the conceptual basis for the quantisation procedures in field theory

09/28 Quantum Field Theory: Feynman diagrams [2, 5, 6, 7, 8]
deriving Feynman diagrams as the perturbative expansion of the scattering amplitude that was introduced in the previous lecture

10/05 Quantum Field Theory: Renormalisation [5, 6, 7, 9]
showing the need for renormalisation as the connection between theory and expermient; giving an example of renormalisation in the scalar ABC-toy-model

10/12 Quantum Field Theory: Gauge theory [3, 5, 6, 7, 10]
discussing general properties of gauge theories; introducing gauge fixing as a possibility to define the propagator; quantising the gauge field in the path-integral formalism, including the proper treatment of gauge-fixing

10/19 Quantum Field Theory: QED [5, 6, 7, 10]
renormalising quantum electro dynamics and discussing the elementary one-particle-irreducible diagram, including dimensional regularisation; evaluation of the photon propagator gives the Lamb-shift in the low energy approximation

10/26 Quantum Field Theory: QCD [5, 6, 7, 10]
energy dependent evaluation of the vector boson propagator leads to an understanding of the running coupling constant; further analysis gives the renormalisation group equation; renormalising QCD shows the opposite sign of the beta function which explains asymptotic freedom and confinement; discussing parton distribution functions as an effective renormalisation prescription for the analysis of high energy collider experiments

11/09 The Standard Model: Particle content [2, 3, 11, 12]
An overview over the Standard Model and its particles

11/16 The Standard Model: Higgs Mechanism [2, 3, 11, 12]
explanation of the Higgs mechanism in the electro-weak Standard Model

11/23 The Standard Model: Particle detection [2, 11]
discussing, how we can connect the classical approach of the expermiental detectors with the quantum nature of the detected particles; principle mechanisms for detecting particles; overview over the CMS detector

11/30 Outlook: Supersymmetry (SUSY) — MSSM [5, 10, 14]
discussing supersymmetry as an extension of the Poincaré algebra; motivating the construction of a supersymmetric field theory; applying the principles to construct schematically the minimal supersymmetric Standard Model (MSSM); discussing the relevance of the MSSM to grand unification and to cosmology; motivating supergravity

12/07 Outlook: Strings, Stringtheory, Superstrings [15, 16]
history and concepts of string theory; introducing the bosonic string; motivating the introduction of superstrings; branes as boundary conditions, becoming dynamical objects; discussing compactification and dualities, leading to the conjecture of M-theory

References

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