Exam preparation hints

Symmetries in Physics

Winter 2019/20

Lecturer: PD Dr. G. von Hippel

1. *Assumed background knowledge (not examined explicitly)*

   From mathematics: groups and group homomorphisms; conjugacy classes, subgroups, cosets, normal subgroups, simple groups; Lagrange's theorem; Cayley's theorem.

   From physics: classical electrodynamics and field theory; non-relativistic quantum mechanics; special relativity; particle content of the Standard Model; low-mass hadrons.

2. *Examinable course contents*

   Lie groups and Lie algebras: basic properties, compactness and connectedness, simplicity and semisimplicity; Cartan metric, Casimir operators, Cartan subalgebra, roots and root vectors, quantization of roots (broad outline only); positive and simple roots, Cartan matrix, Dynkin diagrams, constraints on Dynkin diagrams (broad outline only), Cartan-Dynkin classification; exceptional Lie groups, isomorphy in exceptional cases.

   Representation theory: basic notions, equivalence of representations, dual and conjugate representation, real, pseudoreal and complex representations; irreducible representations, complete reducibility, unitary representations; Maschke's theorem; Schur's lemmas; Great orthogonality theorem; characters, character orthogonality, character tables for finite groups; Clebsch-Gordan decomposition, Wigner-Eckart theorem; application of Young diagrams to SU(N) representations (methods only); representations of Lie algebras, weights, fundamental weights, highest weight.

   Physical applications: Noether's theorem; isospin in pion-nucleon reactions; eightfold way and SU(3) quark model; algebraic solution of the hydrogen atom (broad outline only); representation theory of the Lorentz and Poincaré groups, spin and helicity; Weyl and Dirac spinors; local symmetries and gauge fields; construction of gauge-invariant actions; Goldstone's theorem (for a fundamental scalar field); pions as (pseudo-)Goldstone bosons in chiral perturbation theory; Higgs effect (for a fundamental scalar field).

   The focus of the exam will generally be on the physical applications.

3. *Place and time*

   The dates and times have been agreed individually with each candidate.

   The exams for the module "Vertiefende Vorlesung" take place in my office (Institut für Kernphysik, Johann-Joachim-Becher-Weg 45, 2nd floor, room 2-100).