GAUGE FIELD THEORY

Prof. Alexander Mitov

This course is an introduction to the gauge field theories of modern Particle Physics, focusing on the gauge-invariant Lagrangian of the Standard Model of electroweak and strong interactions, with particle masses introduced via spontaneous symmetry breaking (the Higgs mechanism). There are no formal prerequisites for the course though it would be helpful to have attended the Part III Particle Physics or Quantum Field Theory Major Options; for those who have not, the lectures cover the essential material, including the necessary relativistic quantum field theory.

Relativistic quantum mechanics: Covariant notation; transition rates; phase space; two-body decay and scattering; interaction and scattering via particle exchange; Feynman graphs; Klein-Gordon equation; Dirac equation; free-particle spinors; helicity and chirality; electromagnetic interactions, photons; charge conjugation; gamma matrix algebra; Compton scattering.

Relativistic quantum fields: Classical field theory, Lagrangian densities; Klein-Gordon field; Fourier analysis; second quantization; single-particle and two-particle states; quantising the electromagnetic field; vacuum energy and normal ordering; complex fields; symmetries and conservation laws; Noether's theorem; Dirac field; spin-statistics theorem; Majorana fields.

Gauge field theories: Gauge symmetry in QED; non-Abelian gauge symmetry; strong interactions, QCD; weak interactions; electroweak interactions; spontaneous symmetry breaking; gauge boson masses; the unitary gauge; Yukawa interactions, quark and lepton masses; Higgs mechanism; parameters of the Standard Model; properties of the Higgs boson.

Renormalisation: Ultraviolet divergences; renormalisability; dimensions of fields and couplings; non-renormalisable interactions and effective theories.

Beyond the Standard Model: neutrino masses, the seesaw mechanism; grand unification, SU(5).

BOOKS

Quantum Field Theory, Mandl F and Shaw G (2nd edn Wiley 2009)
A Modern Introduction to Quantum Field Theory, Maggiore M (OUP 2005)
Gauge Theories in Particle Physics, Aitchison I J R and Hey A J G (3rd edn 2 vols IoP 2003)
Quantum Field Theory in a Nutshell, Zee A (2nd edn Princeton University Press 2010)
An Introduction to Quantum Field Theory, Peskin M E and Schroeder D V (Addison-Wesley 1995)