The Standard Model and LHC Phenomenology

Oxford Master Course in Mathematical and Theoretical Physics (MMathPhys)

http://mmathphys.physics.ox.ac.uk/

Trinity Term 2015

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The lectures will take place on **Fridays** each week during Trinity Term 2015 **from 11.00 to 13.00**, at the **Conference Room, Denys Wilkinson Building**. The first lecture will take place on Friday May 1st 2015.

Syllabus

- The Standard Model: an historical introduction.
- The strong interaction. Motivation for QCD. The hadron spectrum. Evidence for a new quantum degree of freedom: color. Evidence for a new gauge boson: the gluon. Scaling in deep-inelastic scattering.
- The QCD Lagrangian. Similarities and differences with QED Feynman rules. Color algebra and color flow. Symmetries of QCD.
- Asymptotic freedom. QCD in electron-positron annihilation. Renormalization group equations. The running of the strong coupling constant. Sterman-Weinberg jets and radiative corrections. Soft and collinear singularities in NLO matrix elements. Infrared and collinear safe observables.
- Perturbative QCD in processes with hadrons in the initial state. QCD factorization and the parton model. Parton Distribution Functions. The parton model and radiative corrections. Factorization of initial state divergences and DGLAP evolution of parton distributions.
- State-of-the-art perturbative QCD at the LHC. Collider kinematics. Jet production at hadron colliders. Drell-Yan production and impact on PDFs. Theoretical uncertainties in perturbative QCD. Searches for New Physics at the LHC.
- Parton fragmentation in perturbative QCD. Parton evolution as a semi-classical branching process. Monte Carlo event generators and realistic simulation of hadronic final states. Jet reconstruction in hadronic collisions. Jet algorithms and jet substructure methods.
- Electroweak interactions. Historical introduction. Weak decays, Fermi theory, violations of unitarity. Symmetries of the weak interaction. Neutral and charged currents. Experimental evidence for the W and Z bosons.

- $SU(2) \times U_Y(1)$ gauge symmetry and spontaneous symmetry breaking. Mass generation for gauge bosons. The Higgs mechanism. Custodial symmetry and Yukawa masses. Anomaly cancellation. Feynman rules in electroweak theory.

- Higgs phenomenology at hadron colliders. Production channels and decay modes. Comparison with LHC measurements. Unitarization of vector-boson scattering. Higgs pair production. Prospects for Higgs physics at the LHC.

References

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[2] M. D. Schwartz, "Quantum Field Theory and the Standard Model," Cambridge University Press (2014).

[3] J. Collins, "Foundations of perturbative QCD," Cambridge monographs on particle physics, nuclear physics and cosmology (2014).

[4] C. P. Burgess and G. D. Moore, "The standard model: A primer," Cambridge, UK: Cambridge Univ. Press (2007).

[5] R. K. Ellis, W. J. Stirling and B. R. Webber, "QCD and collider physics," Camb. Monogr. Part. Phys. Nucl. Phys. Cosmol. **8**, 1 (1996).

[6] G. Dissertori, I. G. Knowles and M. Schmelling, "Quantum Chromodynamics: High energy experiments and theory," International series of monographs on physics, 115, Oxford Science Publications.

[7] J. Rojo, "The Strong Interactions and LHC phenomenology", lecture notes available online at http://juanrojo.com/teaching

[8] G. Zanderighi, "QCD and collider physics", lecture notes available online at http://www2.physics.ox.ac.uk/sites/default/files/QCDLectures.pdf

[9] P. Nason, "Introduction to QCD", lecture notes available online at http://moby.mib.infn.it/~nason/misc/QCD-intro.ps.gz