A first course on Quantum Field Theory

3 de Outubro de 2012

1 List of topics

Total Number of planned lectures = 11. Each lecture is 45+45 min with a short 5 minute break.

1. Motivation and Background concepts (3 lectures ~ 4H30):
   (a) Motivation: Scales, units, different limits where QM and special relativity are important.
   (b) Some particle physics concepts with examples:
      i. Review of SM of particle physics with scales & conservation laws.
      ii. Probing short scales: Definition of cross-section and decay widths.
   (c) Revision of special relativity & connection to QFT:
      i. Galilean transformations vs Postulates of Special relativity, Lorentz transformations and relativistic equations of motion
      ii. Relativistic kinematics applied to particle physics examples
   (d) Revision of quantum mechanics & connection to QFT :
      i. Postulates, physical interpretation, observables & quantum dynamics
      ii. Two paradigmatic examples: Harmonic oscilator & born approximation
2. Quantization of the scalar field (3 lectures ~4H30):
   (a) Mathematical tools
   (b) Lorentz transformations revisited
   (c) Lagrangian, Equations of motion, classical solutions
   (d) Noether's theorem
   (e) Hamiltonian and quantisation
   (f) Schrodinger vs Heisenberg Picture and propagators
3. Interacting scalar field theory (2 lectures ~3H00)
   (a) Interaction picture & physical quantities
   (b) Cross sections and decay widths in QFT
   (c) Wick theorem & Feynman rules

(d) physical processes

4. The Dirac field (2 lectures ~ 3H00):

   (a) Physical motivation, Lorentz transformations, Equations of motion
   (b) Plane waves solutions, Noether current
   (c) Hamiltonian, quantisation
   (d) particle states & propagator (Feynman rule for free theory)

5. Yukawa theory and the Standard Model Higgs (1 lectures ~ 1H30):

   (a) Interaction picture terms arising in the S-matrix expansion & Feynman rules summary
   (b) An example: Higgs decay to fermions at the LHC & comparison to other channels.
   (c) If time left, summary of QED rules

2 References

The main references are indicated with a star (*)

Quantum Field Theory:

M. E. Peskin and D. V. Schroeder, An introduction to quantum field theory. Reading, USA: Addison-Wesley, 1995. 842 p.

Introduction to special relativity

- Stephani, Hans, Relativity: An introduction to special and general relativity, Cambridge University Press. (*)
- Schutz, Bernard F., A first course in general relativity, 2004, Cambridge University Press.

Introduction to Quantum mechanics & particle physics

- Sakurai, J. J., Moden quantum mechanics, 1994, Adison-Wesley. (*)
- Bettini, Alessandro, Introduction to Elementary Particle Physics, 2008, Cambridge University Press.
- Griffiths, D., Introduction to elementary particles, John Wiley & Sons Inc., 1987.
- Halzen, Francis, Martin, Alan D., Quarks and Leptons: An introductory course in modern particle physics, 1984, John Wiley & Sons.