Quantum Electrodynamics

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- **Textbook**
  Nicola Cabibbo, Luciano Maiani & Omar Benhar:
  An Introduction to Gauge Theories.
  Suggestions for further readings can be found in the Bibliography.

Syllabus

1. **The Feynman Path Integral**
   Transition amplitude in quantum mechanics. Lattice approximation. The classical limit. Time as a complex variable. Statistical Mechanics. Green's Functions. Towards a field theory. Generating functional for the free scalar field.

2. **Perturbation theory of $\lambda\phi^4$ theory**
   Perturbative expansion of the generating functional. Connected parts and vacuum diagrams. Two-point Green's function in perturbation theory.

3. **Spectral representation of the two-point Green's function**

4. **Scattering processes and the S-matrix**
   Asymptotic "in" and "out" states. Scattering amplitude and the S-matrix. LSZ reduction formulae for the $\lambda\phi^4$ theory. Feynman rules for the S-matrix elements.

5. **The electromagnetic field**
   Gauge fixing. The deWitt-Faddeev-Popov method. Generating functional and propagator.

6. **Fermion fields**
   Anticommuting variables. Definition and properties of Grassmann variables. Generating functional and propagator of the free Dirac field.

7. **Quantum Electro-Dynamic (QED)**
   Reduction formulae for QED. Calculation of the Compton scattering amplitude. Renormalisation of QED. Significance of renormalisation in quantum field theory. Dimensional regularisation. Order α correction to the free photon propagator. Charge renormalisation. The full propagator and vacuum polarisation. Electron propagator and vertex to order α. Ward identity.

8. **Applications of QED** Scattering in an external field. Bremsstrahlung and infrared divergence. Lamb shift. One-loop calculation of the vacuum polarisation tensor. The anomalous magnetic moment. Renormalisation group of QED. The Gell-Mann and Low equation.