Chapter 1

Quantum Electrodynamics (QED) : Maxwell's equation , Dirac equation .

Feynman diagrams, Quantum mechanics, Relativity

Physical intuition $\rightarrow$ bottom-up approach $\rightarrow$ many gaps

Goal is the top-down approach

Cross section calculation

$$\frac{d\sigma}{d\Omega} = \frac{1}{64\pi^2 E_{cm}^2 \cdot |M|^2}$$

(CM scattering)

For the QED, The 'M' is not known.

The best we can do : Set M as a perturbation series of QED, and evaluate the first term.

The Feynman diagram $\rightarrow$ visualize the perturbation.

In QM perturbation theory, to first order, the amplitude is,

$$\langle \text{ final state } | \ H_1 \ | \text{ initial state } \rangle$$

This is the first order, but the hamiltonian can not mediate the two state, but gamma does it.
So, expand this equation to the next order with γ.

For $(e^- + e^+ \rightarrow \mu^- + \mu^+)$,

$$\text{M} \sim \langle u^+ u^- \ |H_1| \ \gamma \ \rangle^u \ \langle \gamma | H_1 | e^+ e^- \rangle_u$$

1. External electron lines : $|e^+ e^-\rangle$
2. External muon lines : $\langle e^+ e^-|$
3. The vertices : H_1
4. Internal photon line : $|\gamma\rangle\langle\gamma|$