QFT

Chapter 63: The Vertex Function in Spinor Electrodynamics

Introduction

- Our renormalization condition for the propagator is either on-shell (make $m = m_{ph}$) or minimal subtraction (cancel off the divergent parts only).

- For the vertex, we've had discussions about how to renormalize this.
  - Up to now, we've defined the "exact" vertex function equal to the coupling constant after setting the momenta to zero.
  - This is mathematically convenient, but physically meaningless.
  - Now, we have the chance to do something more physically meaningful. The idea is that we can do an "on-shell" scheme, since the massless photon makes this compatible with momentum conservation.

Vertex Function Normalization

- Consider electron-electron scattering.
  - As the photon momentum decreases, the exact propagator approaches the tree-level propagator
  - So, we can normalize the electron-electron-photon vertex function by requiring it to approach its tree level value as $q^2 \rightarrow 0$.
  - Physically, this makes sense, as $q \rightarrow 0$, the electron deflects very little during the scattering – this is how we measure charge via Coulomb's Law.

- Requiring the vertex function to approach its tree-level value gives this:

$$\overline{u}_s(p)V^\mu(p,p')u_s(p) = e\overline{u}_s(p)\gamma^\mu u_s(p) = 2ep^\mu$$

Form Factors

- Now we can use this, in our example, to figure out the entire vertex factor.

- It is convenient to factor our answers into a particular form, with the information encoded into “form factors”

$$\overline{u}_{s'}(p)V^{\mu}(p,p')u_s(p) = e\overline{u}_s(p)\left[F_1(q^2)\gamma^{\mu} - \frac{i}{m}F_2(q^2)S^{\mu\nu}q_{\nu}\right]u$$

- Conceptually, Form Factors are designed to give the properties of certain particle interactions, without including all of the underlying physics. They can be determined experimentally.