QFT

Chapter 63: The Vertex Function in Spinor Electrodynamic
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 $q^2 \to 0$.
  • Physically, this makes sense, as $q \to 0$, 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:
  $$\bar{u}_s(p)V^\mu(p, p')u_s(p) = e\bar{u}_s(p)\gamma^\mu u_s(p) = 2ep^\mu$$
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”

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

• 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.