

Due March 15, 2018

Reading

Peskin & Schroeder Chapter 10

Suggested further reading: Weinberg Volume 1, Sections 9.4-9.5

Problems

1. *Electron form factors at one loop.* Consider the vertex function with two fermions and a gauge field in a theory consisting of a $U(1)$ gauge field coupled to a Dirac fermion (i.e., QED). The result is expressed in terms of form factors $F_1(q^2)$ and $F_2(q^2)$, normalized according to $F_1(0) = 1$.

a) Use the $\overline{\text{MS}}$ convention for the renormalized coupling $g(\mu)$,

$$g_{\text{bare}} = Z_g \mu^\epsilon g(\mu), \quad (1)$$

where Z_g is a series of $1/\epsilon$ poles. Find Z_g through one loop order. Compute the beta function,

$$\beta(g) \equiv \frac{d}{d \log \mu} g(\mu). \quad (2)$$

b) Compute the onshell wavefunction renormalization factors, Z_ψ and Z_A using dimensional regularization for UV divergences, and two different prescriptions for IR divergences: first, a photon mass regulator, and second dimensional regularization. What values do Z_ψ and Z_A take when the electron mass vanishes and dimensional regularization is used for IR divergences?

c) Finally, compute the form factor $F_1(q^2)$ as a Taylor expansion in q^2 , through first order in q^2 . Is the result independent of UV regulator? Is the result independent of IR regulator?