4 One-Loop Corrections of QCD

We will work within dimensional regularization of loop momentum integrals.

4.1 Quark self-energy

Diagram

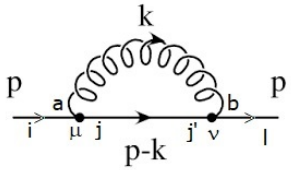

Figure 4.1: Quark self-energy diagram.

Its expression

$$-i\Sigma_{ij}(p^2) = (-iq)^2\mu^{4-d}\int \frac{d^dk}{(2\pi)^d}\gamma^\mu t^a_{il}\frac{i(\not{p}-\not{k}+m)\delta_{ll'}}{(p-k)^2-m^2}\gamma^\nu t^b_{l'j}\frac{-ig_{\mu\nu}\delta_{ab}}{k^2} \quad (4.1)$$

$$\rightarrow \Sigma_{ij}(p^2) = iq^2\left(t^a_{il}t^a_{lj}\right)\frac{\mu^{4-d}}{(2\pi)^d}\int d^dk\frac{\gamma^\mu(\not{p}-\not{k}+m)\gamma_\mu}{((p-k)^2-m^2)k^2} \quad (4.2)$$

It looks similar to electron self-energy in QED with extra *color factor* term. Using the fact that

$$t^a_{il}t^a_{lj} = \frac{4}{3}\delta_{ij}$$

we will have

$$\Sigma_{ij}(p^2) = q^2\frac{4}{3}\delta_{ij}I(p^2,\mu) \quad (4.3)$$

$$I(p^2,\mu) = i\frac{\mu^{4-d}}{(2\pi)^d}\int d^dk\frac{\gamma^\mu(\not{p}-\not{k}+m)\gamma_\mu}{((p-k)^2-m^2)k^2} \quad (4.4)$$

4.2 Gluon self-energy

Diagrams

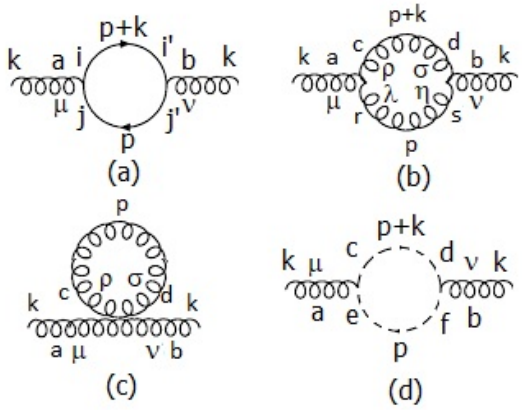

Figure 4.2: Gluon self-energy diagrams.

Their expressions are

$$i\Pi^{ab,\mu\nu}_{(a)}(k^2) = (-)(-iq)^2\mu^{4-d}\int \frac{d^dp}{(2\pi)^d} Tr\left[\gamma^\mu t^a_{ij}\frac{i(\not p+\not k+m)\delta_{ii'}}{(p+k)^2-m^2}\gamma^\nu t^b_{j'i'}\frac{i(\not p+m)\delta_{jj'}}{p^2-m^2}\right] \quad (4.5)$$

$$\rightarrow \Pi^{ab,\mu\nu}_{(a)}(k^2) = iq^2\left(t^a_{ij}t^b_{ji}\right)\frac{\mu^{4-d}}{(2\pi)^d}\int d^dp\frac{Tr\left[\gamma^\mu(\not p+\not k+m)\gamma^\nu(\not p+m)\right]}{((p+k)^2-m^2)(p^2-m^2)} \quad (4.6)$$

4.3 Quark-gluon vertex correction

Diagrams

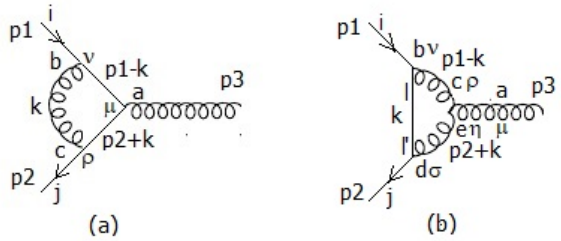

Figure 4.3: Quark-gluon vertex correction diagram.