Lecture 7 : Quantum Chromodynamics -2

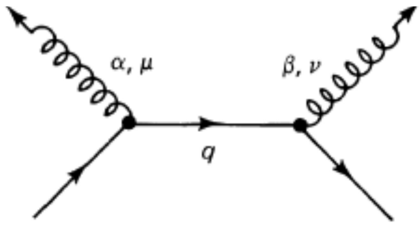
Pair annihilation of quark and antiquark in quantum chromodynamics :

$$q + \overline{q} \rightarrow g + g$$

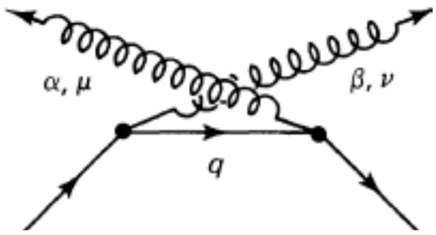
Similar process in QED is the pair annihilation of electron-positron pair :

$$e^{-} + e^{+} \rightarrow \gamma + \gamma$$

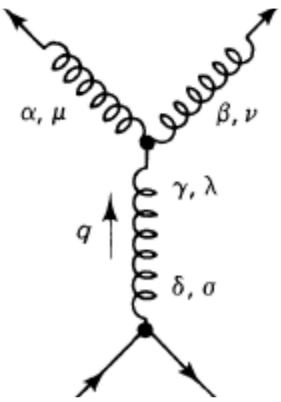
In QCD there are three Feynman diagrams for $q + \overline{q} \rightarrow g + g$ at the tree level :



quark exchange



quark exchange (twisted)



gluon exchange

For the spin singlet and color singlet case the total differential cross section becomes :

$$\sigma = \frac{2}{3}\frac{4\pi}{cv}\left(\frac{\hbar\alpha_s}{m}\right)^2$$

which is to be compared with the QED pair annihilation formula. For all the details of the above derivation study the Chapter 9 Section 3 of the D.Griffiths textbook "Int.Elementary Particles J.Wiley.

Basics of asymptotic freedom :

In the chapter on QED we have seen that loop diagrams of the vacuum polarization makes the effective charge of the electron become a function of the momentum transfer and higher order diagrams can be handled via the renormalization techniques.

A similar case occurs in QCD : quark-antiquark pairs lead to a screening of the quark color.

In the case 11n > 2f (where n is the number of colors and f is the number of flavors, antiscreening effects dominate and at shorter distances the strong coupling constant becomes relatively weaker. In SM since n=3 and f=6 the condition is obviously satisfied and QCD is asymptotically free.

For more information study the Chapter 9 Section 4 and 5 of the D.Griffiths textbook "Int.Elementary Particles J.Wiley.

Homework and Study Problems :

Examine and try to solve some of the problems listed from the same textbook by D.Griffiths.

Solve Problem 9.11

Solve Problem 9.12

Solve Problem 9.13

Solve Problem 9.14

Solve Problem 9.15

Solve Problem 9.16

Solve Problem 9.17

Solve Problem 9.18