Lecture 6 : **Quantum Chromodynamics -1**

Feynman rules for quantum chromodynamics

Coupling strength for QED : $g_e = \sqrt{4\pi\alpha}$ here g_e is the charge on the positron

Coupling strength for QCD : $g_s = \sqrt{4\pi\alpha_s}$

To specify the colors of the quarks one uses column vectors :

$$r = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \qquad b = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \qquad g = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$$

To specify the colors of the gluons we need column vectors a_i ; $i = 1,.....,8$:

a_i with eight components:

$$a_1^T = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

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$$a_8^T = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

Gell-Mann matrices for the SU(3) color group

$$\lambda_1 = \begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}; \quad \lambda_2 = \begin{pmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}; \quad \lambda_3 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{pmatrix};$$

$$\lambda_4 = \begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}; \quad \lambda_5 = \begin{pmatrix} 0 & 0 & -i \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}; \quad \lambda_6 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix};$$

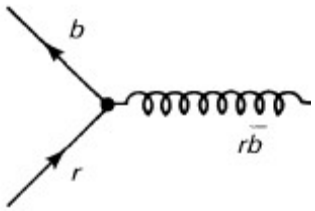
$$\lambda_7 = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{pmatrix}; \quad \lambda_8 = \frac{1}{\sqrt{3}} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{pmatrix}; \quad \lambda_0 = \sqrt{\frac{2}{3}} \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

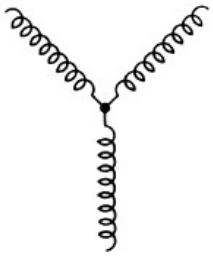
The algebra of these matrices :

$$\left[\frac{\lambda^a}{2}, \frac{\lambda^b}{2}\right] = i f^{abc} \frac{\lambda^c}{2}$$

where f^{abc} is totally antisymmentric structure functions of the $SU_c(3)$ gauge group.

Typical diagrams of QCD interactions :





Feynman rules for the tree level QCD diagrams :

Examine the Chapter Section 1 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 textbook D.Griffiths' "Int. to Elementary Particles"

Solve Problem 9.1

Solve Problem 9.2

Solve Problem 9.3

Solve Problem 9.4

Solve Problem 9.5

Solve Problem 9.6

Solve Problem 9.7

Solve Problem 9.8

Solve Problem 9.9

Solve Problem 9.10

Solve Problem 9.10

Quark-quark and quark-antiquark interactions in QCD

Color factor for the **octet** configuration

Color factor for the **singlet** configuration

Color factor for the **sextet** configuration

For the details of the derivations see the Chapter 9 Section 2 of the D.Griffiths textbook “Int.Elementary Particles J.Wiley.