

Appendix: Feynman rules for QCD

Propagators:

Gluon propagator (Feynman gauge):

$$\frac{\mu}{a} \overset{k}{\circlearrowright} \overset{\nu}{b} - i\delta_{ab}g_{\mu\nu}/(k^2 + i\epsilon)$$

(Massless) fermion propagator:

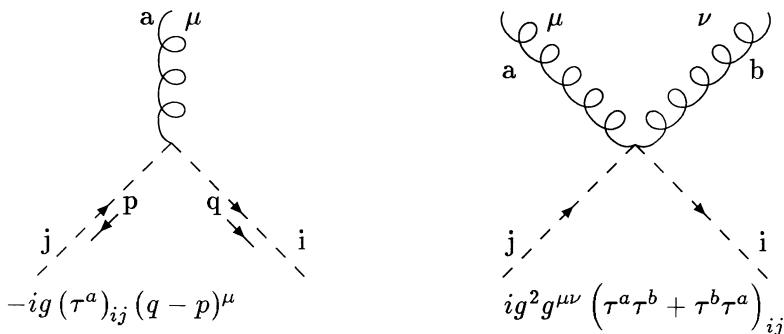
$$\frac{\beta}{i} \overset{k}{\longrightarrow} \overset{\alpha}{j} i\delta_{ij}(\gamma \cdot k)_{\alpha\beta}/(k^2 + i\epsilon)$$

(Massless) scalar propagator:

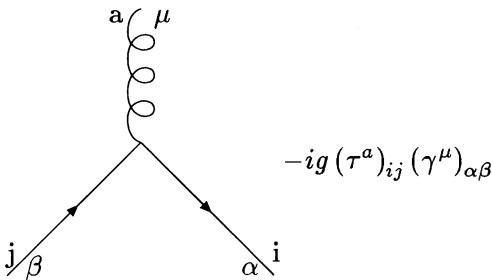
$$\frac{k}{i} \overset{-}{\longrightarrow} \overset{-}{j} i\delta_{ij}/(k^2 + i\epsilon)$$

Vertices: (momenta are always outgoing)

Scalar–gluon interactions:



Fermion-gluon interaction:



Gluon self-interactions:

Two Feynman diagrams for gluon self-interactions. The left diagram shows a gluon line a^μ splitting into two gluons p_ρ and q_ν , which then interact to produce gluons c and b . The right diagram shows a gluon line a^μ interacting with another gluon line d^σ to produce gluons c and b .

$$ig(T^a)_{bc} [g^{\nu\rho}(q-p)^\mu + g^{\rho\mu}(2p+q)^\nu - g^{\mu\nu}(p+2q)^\rho]$$

$$ig^2 (T^e)_{ab} (T^e)_{cd} (g^{\mu\rho}g^{\nu\sigma} - g^{\mu\sigma}g^{\nu\rho}) + \nu \stackrel{b \leftrightarrow c}{\leftrightarrow} \rho + \nu \stackrel{b \leftrightarrow d}{\leftrightarrow} \sigma$$

The gauge coupling constant is g ($\alpha_s = g^2/4\pi$).

The matrices $(\tau^a)_{ij}$ are the matrices of the colour group in the representation of the quarks or colour scalar particles.

The matrices $(T^a)_{bc} = -if_{abc}$ are the colour matrices in the adjoint representation and f_{abc} are the structure constants of the colour group.

In addition there is a further factor of $-i$ accompanying each amplitude so that it is an element of the T -matrix rather than the S -matrix ($S = \mathbb{1} + iT$).