Appendix A

Conventions

A.1 Dirac matrices

The following convention for the the Euclidean γ matrices is used:

$$\gamma_0 = \begin{pmatrix} 0 & 0 & +1 & 0 \\ 0 & 0 & 0 & +1 \\ +1 & 0 & 0 & 0 \\ 0 & +1 & 0 & 0 \end{pmatrix}, \quad \gamma_1 = \begin{pmatrix} 0 & 0 & 0 & +i \\ 0 & 0 & +i & 0 \\ 0 & -i & 0 & 0 \\ -i & 0 & 0 & 0 \end{pmatrix},$$
$$\gamma_2 = \begin{pmatrix} 0 & 0 & 0 & +1 \\ 0 & 0 & -1 & 0 \\ 0 & -1 & 0 & 0 \\ +1 & 0 & 0 & 0 \end{pmatrix}, \quad \gamma_3 = \begin{pmatrix} 0 & 0 & +i & 0 \\ 0 & 0 & 0 & -i \\ -i & 0 & 0 & 0 \\ 0 & +i & 0 & 0 \end{pmatrix}. \tag{A-1}$$

They are hermitian and satisfy the anti-commutation relation

$$\{\gamma_\mu, \gamma_\nu\} = 2\delta_{\mu\nu}\,. \tag{A-2}$$

With the above choice for γ_0 we have chosen the chiral representation where $\gamma_5 = \gamma_1\gamma_2\gamma_3\gamma_0$ is diagonal:

$$\gamma_5 = \begin{pmatrix} +1 & 0 & 0 & 0 \\ 0 & +1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}. \tag{A-3}$$

The projection operators on left- and right-handed chirality then read

$$P_- = \frac{1}{2}(1-\gamma_5)\,, \qquad P_+ = \frac{1}{2}(1+\gamma_5)\,, \tag{A-4}$$

respectively.

A.2 Generators of SU(3)

The 3×3 traceless hermitian generator matrices of SU(3) in the fundamental representation may be chosen to have the standard form (Gell-Mann, 1962):

$$
\begin{aligned}
&\lambda^1 = \frac{1}{2}\begin{pmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \lambda^2 = \frac{1}{2}\begin{pmatrix} 0 & -i & 0 \\ i & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad \lambda^3 = \frac{1}{2}\begin{pmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \\
&\lambda^4 = \frac{1}{2}\begin{pmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix}, \quad \lambda^5 = \frac{1}{2}\begin{pmatrix} 0 & 0 & -i \\ 0 & 0 & 0 \\ i & 0 & 0 \end{pmatrix}, \\
&\lambda^6 = \frac{1}{2}\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}, \quad \lambda^7 = \frac{1}{2}\begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & -i \\ 0 & i & 0 \end{pmatrix}, \quad \lambda^8 = \frac{1}{2\sqrt{3}}\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -2 \end{pmatrix},
\end{aligned}
\tag{A-5}
$$

They are normalized according to

$$\mathrm{Tr}(\lambda^a \lambda^b) = \frac{1}{2}\delta_{ab} \tag{A-6}$$

and obey the commutation relation

$$[\lambda^a, \lambda^b] = i f^{abc} \lambda^c \,. \tag{A-7}$$