Phenomenology of Particle Physics
Errata (26/5/24)

1. **p. 4**: Eq. (1.2) The electron-volt is defined as the amount of energy gained by a single electron when it moves through an electric potential difference of one volt, hence one should read:

$$1\ \mathrm{GeV} = 10^9\ e\ (1\ \mathrm{V}) = 1.602\,176\,634 \times 10^{-10}\ \mathrm{J} \quad (\text{exact}) \tag{1}$$

2. **p. 14**: Eq. (1.30), one should read:

$$m = 1\ \mathrm{GeV/c^2} = \frac{10^9\mathrm{eV}}{c^2\,\frac{\mathrm{m}^2}{\mathrm{s}^2}} = \ldots \tag{2}$$

3. **p. 298**: Eq. (9.197), one should read:

$$a_3 a_4 a^\dagger_{x_1} a_{x_1} a^\dagger_{x_2} a_{x_2} a^\dagger_1 a^\dagger_2 \quad \rightsquigarrow \quad -a_3 a_4 a^\dagger_{x_1} a^\dagger_{x_2} a_{x_1} a_{x_2} a^\dagger_1 a^\dagger_2 \quad \rightsquigarrow \quad +a_3 a_4 a^\dagger_{x_1} a^\dagger_{x_2} a_{x_1} a^\dagger_1 a_{x_2} a^\dagger_2 \tag{3}$$

4. **p. 301**: Ex. 9.2, point c, one should read:

   (c) $\pi^+\pi^- \to \pi^0\pi^0$ and $\pi^0\pi^0 \to \pi^+\pi^-$

5. **p. 389**: Eq. (11.295), one should read:

$$\frac{ie^2}{q^2}\bar{v}(p')\gamma_\mu(k_- - k_+)^\mu u(p) \tag{4}$$

   where $q^\mu = k_- + k_+$.

6. **p. 436**: Ex 13.1, Eq. (13.44) should read:

$$\frac{1}{2}\sum_{spins}\mathcal{M}\mathcal{M}^* = \frac{1}{2}\left(\frac{e\lambda}{4m_{\ell^*}}\right)^2 q_\mu q_\alpha \epsilon^*_\nu \epsilon_\beta\, \mathrm{Tr}\left[\not{p}_2(\gamma^\mu\gamma^\nu - \gamma^\nu\gamma^\mu)(1-\gamma^5)\not{p}_1(1+\gamma^5)\left(\gamma^\beta\gamma^\alpha - \gamma^\alpha\gamma^\beta\right)\right] \tag{5}$$

7. **p. 437**: Ex 13.1, Eq. (13.46) should read:

$$d\Gamma = \frac{1}{8m_{\ell^*}}\frac{1}{(2\pi)^2}\left(\frac{e\lambda}{4m_{\ell^*}}\right)^2\left[32(m^3_{\ell^*}E_2 - m^2_{\ell^*}E^2_2)\right]\frac{p_2^2 dp_2 d\Omega d^3\vec{k}}{\omega E_2}\delta(m_{\ell^*} - E_2 - \omega)\delta^3(-\vec{p}_2 - \vec{k}) \tag{6}$$

8. **p. 444**: In point 3, one should read “magnetron frequency” instead of “magneton frequency”.

9. **p. 463**: Eq. (14.123) should read $\vec{E}(x,y,z) = -\frac{V_0}{r_0^2}(x,y,-2z)$ instead of $\vec{E}(x,y,z) = \frac{V_0}{r_0^2}(x,y,-2z)$.

10. **p. 463**: Accordingly, Eq. (14.124) should also have a minus sign in front of the first term:

$$\begin{pmatrix}\ddot{x}\\ \ddot{y}\\ \ddot{z}\end{pmatrix} = -\frac{eV_0}{mr_0^2}\begin{pmatrix}x\\ y\\ -2z\end{pmatrix} + \omega_0\begin{pmatrix}\dot{y}\\ -\dot{x}\\ 0\end{pmatrix} \tag{7}$$

11. **p. 502**: Eq. (16.28) should have absolute values.

$$
\begin{aligned}
\left|F_S(\vec{q}^2)\right| &= \left|\frac{3}{qa^3}\int_0^a \mathrm{d}r r\sin(qr)\right| = \left|\frac{3}{qa^3}\left[\frac{r\cos qr}{q}\Big|_0^a - \int_0^a \frac{\cos qr}{q}\mathrm{d}r\right]\right| \\
&= \frac{3}{qa^3}\left|\frac{a\cos qa}{q} - \frac{\sin qa}{q^2}\right| = \left|\frac{3\cos qa}{(qa)^3}\left[qa - \tan qa\right]\right| \qquad (8)
\end{aligned}
$$

12. **p. 529**: Bottom of the page. “Such discrimination is not possible...”. The end of the sentence should read $I_3 = Y = 0$ instead of $I = Y = 0$.

13. **p. 540**: Eq. (17.68) should read:

$$
\Gamma(\pi^0 \to \gamma\gamma) = \left(\frac{\alpha}{3\pi}\right)^2 N_C^2(Q_u^2 - Q_d^2)\frac{m_\pi^3}{8\pi f_\pi^2} \qquad (9)
$$

14. **p. 551**: Ex 17.3, point c, one should read $\sin\theta = 1/\sqrt{3}$ instead of $\theta = 1/\sqrt{3}$.

15. **p. 658**: Table 21.1, The Q-value for neutron decay should be 782.3 keV instead of 7823 keV.

16. **p. 758**: Ex 23.5, point a, The fourth term has a sign mistake and the entire expression should read:

$$
\begin{aligned}
\frac{1}{2}\sum|\mathcal{M}|^2 &= 8\Big[\left(g_L^2 g_L'^2 + g_R^2 g_R'^2\right)(p_1\cdot p_4)(p_2\cdot p_3) + \left(g_L^2 g_R'^2 + g_R^2 g_L'^2\right)(p_1\cdot p_3)(p_2\cdot p_4) \\
&\quad - m_a m_b\, g_L g_R\left(g_L'^2 + g_R'^2\right)(p_3\cdot p_4) + m_c m_d\,\left(g_L^2 + g_R^2\right) g_L' g_R'(p_1\cdot p_2) \\
&\quad - 4 m_a m_b m_c m_d\, g_L g_R g_L' g_R'\Big]
\end{aligned}
$$

17. **p. 814**: Eq. (26.91) should read $\sigma(e^+e^- \to Z^0 \to \ell^+\ell^-) = ...$ instead of $\sigma(e^+e^+ \to Z^0 \to \ell^+\ell^-) = ...$

18. **p. 814**: Eq. (26.93), same

19. **p. 814**: Eq. (26.94), same

20. **p. 994**: Appendix A.13, the first sentence should refer to “Gauss’s theorem” instead of “Stokes’s theorem”.

21. **p.1039**: Appendix E.4, The theorem **[TS10]** has a sign mistake and should read: **[TS10]**: $\mathrm{Tr}\left(\gamma^5 \not{a}\not{b}\not{c}\not{d}\right) = -4i\epsilon_{\mu\nu\alpha\beta}a^\mu b^\nu c^\alpha d^\beta$