# Errata

Last update 10/02/21

Aime la vérité, mais pardonne à l'erreur (Voltaire)

## Chapter 2

Page 16

P|\gamma> = P|g> = -1

Should be split into two equations :

P|\gamma> = = - |\gamma> and P|g> = -|g>

Page 21

Eqn 2.8

Last two lines have wrong sign. Should be

=J^2-J^2_z-J_z

=J^2-J_z(J_z+1)

Page 27

Part (8) the factor i/3! Should be 1/3!

Last line “Chapter 5” should be “Chapter 6”

Page 29

First line

“…identify the eigenvalues:”

Should be

“… identify the eigenvalue of C^2 and the coefficients C_{\/pm}”

Eqn 2.9

The first line: change “m(m-1)” to “m(m+1)”

Page 33. Eqn preceding 2.33 there should be a subscript j d^3p_j

Page 40

In the first line of the flux factor, the square root symbol over the lambda should extend to over the bracket as well.

Page 45

Bottom of page \epsilon_{ijk} should be \epsilon^{ijk}

## Chapter 3

Page 49

After “The requirement that E_s(R)=0”

Need to state that the first zero of the J_0 Bessel function is J_0(2.40)=0, therefore kR=2.40 and hence lambda=(2*pi/(2.4))*R

Page 55 eqn 3.18 (Checked with *uspas.fnal.gov/materials/09VU/Lecture2.pdf).* The denominator should be R^2 not R.

Page 51

After eqn 3.8

“\eta_{RF}<0” should be “\eta_{RF}>0”

And

“higher momentum eta_{RF}>0” should be “higher momentum eta_{RF}<0”

Page 52. In equation 3.14 “z” should be “s”

Page 51. “for injection … \eta_{rf}<0” should be “injection … \eta_{rf}>0” and “higher momentum .. \eta_{rf}>0” should be “higher momentum .. \eta_{rf}<0”

Page 56 eqn 3.20 remove “l” from k [m^{-2}]=qgl/p.

Page 56 eqn 3.21 the last term should be $l/(f_1\ f_2)$ not $l/f^2$ .

Page 56 footnote 13. “d” should be “l”.

Page 63 sec 3.5

“the number of produced” should be “the rate of produced”

Change N to R in eqn 3.30

Page 65

Need to add a footnote to explain that the horizontal and vertical Q values are not related to the Q-values of the RF cavities discussed in section in 3.1.3.

## Chapter 4

Eqn 4.1 should be

$$\frac{d\sigma}{dq^2} = \frac{4\pi\alpha^2}{q^4\beta^2}$$

Equation 4.6 should have a square root around the term (x/X_0)

In equation 4.25 and 4.26

$[\ln(b/a)]^3$ Should be $\ln(b/a)$

Page 77

After eqn 4.8 should add: $N_A$ is Avogadro's number, Z is the atomic number and A is the atomic mass number (number of protons and neutrons).

Page 83

Eqn 4.14 In both lines the factor of 4q/L should be $q/(L\pi)$. Also the second factor of $(n\pi/L)$ should be removed in the second line.

Page 88

eqn 4.25. The curly bracket should be on the right of dE rather than on the left

Page 90

Fig 4.15 There shouldn't be a large space between "anode" and "wires".

Page 91

"… from the wire to the anode" should be "… from the wire to the cathode"

Page 93 eqn 4.35 should have a – sign on the right hand side

\grad ^2 V = - \rho/epsilon

Page 97 eqn 4.42.

There is a missing factor of q in the denominator

$\sigma(1/p)=8\delta s/0.3Bql^2$

Page 98

Line 6 "1/p" should be "p"

Equation 4.43 the term "Dp" should be "D/p"

Change "where C is the term due to multiple scattering and D is the term due to measurement error" to be "where D is the term due to multiple scattering and C is the term due to measurement error"

Page 186

Table 7.2 The parity transformation for the Axial vector ($4^{th}$ entry) should be (-, +,+,+)

Exercises:

4.3

Calculate the Fourier coefficients for a 'top-hat' function defined by f(x) = 1 for 0 < x < a and 0 elsewhere. Use this result to derive eqn 1.17 starting from eqn 1.16.

*** corrected question ***

Calculate the Fourier coefficients for the periodic function defined by f(z) = z/L for 0 < z < L and f(z) = 0 for −L < z < 0 (the function repeats periodically). Use this result to derive eqn 1.17 starting from eqn 1.16.

## Chapter 5

p116 sec 5.1.1

Change the large S to small s at the top p 117:

line 1: S = 1 -> s = 1;

line 4: S=0, S_z =0 -> s=0, s_z =0:

line 5: S=1, S_z=0 -> s=1, s_z=0; S=1 -> s=1;

line 6: S=0 -> s=0 .

Page 122

lamba_2 is wrong. It should have -i in the first row and i in the second row instead of the 1s
lambda_8 is wrong. There should be a – sign in front of the "2" (this ensures that the matrix is traceless).

Page 124. Remove the "(" before the |ssbar>.

P 134

Change $\psi'$ to $\psi(2S)$ and $\psi''$ to $\psi(3S)$

Delete second bullet point

"since the gluons have charge conjugation and spatial parity both -1" Replace with

"Two or three gluons can be in a colour singlet state, so that a decay to two or three gluons would be compatible with colour conservation. For the analogous decays to photons, we can see that C-parity requires three photons. Gluons are coloured and are therefore not eigenstates of C-parity, however. It turns out the two-gluon decay mode is also forbidden."

Additional explanation:
First consider the decay of the $J\Psi$. This is below threshold to decay into charm mesons. There is another hadronic decay, into pions. Because there are no charm quarks in the final state the charm/anticharm pair in the initial state must annihilate for this decay, and there must be gluon propagators connecting the initial and the final state. As this is again a strong decay the conservation laws for the strong interaction must be obeyed at all stages of the process.
The relevant conserved property is the charge conjugation eigenvalue. For the initial state with $L=0$ and $S=1$, $C=(-1)^{0+1}=-1$. For the final state a decay into a single pion would not satisfy momentum conservation. A decay into $\pi\pi$ ($C=+1$) would violate charge conjugation, so the final state must have at least three pions.
More important is the structure of the intermediate gluon state. It cannot be a single gluon, because the initial state is a colour singlet (it's a particle), and a single gluon can never be a colour singlet.
The gluon is not an eigenstate to charge conjugation, because of its colour content (e.g. a gluon with $r\overline{b}$ becomes $-b\overline{r}$, the -- sign occurs for similar reasons as the -- sign in the charge conjugation eigenvalue for the photon), but a multi-gluon state can be a charge conjugation eigenstate. A two-gluon colour singlet state will contain contributions like $(r\overline{b})(b\overline{r})$. The charge conjugate state will then have $(-b\overline{r})(-r\overline{b})$, so the charge conjugation eigenvalue of the two-gluon state will be $C=+1$, and there can be no strong decay of a $J/\Psi$ into two gluons.
A three-gluon state would contain elements like $(r\overline{b})(b\overline{g})(g\overline{r})\pm(b\overline{r})(g\overline{b})(r\overline{g})$. One of these combinations will have $C=-1$, and so a decay into three gluons is possible.

Page 136

The denominator in the equation for R should be $\sigma(e^+e^- \rightarrow \mu^+ \mu^-)$ not $\sigma(e^+e^- \rightarrow$ hadrons).

## Chapter 6

Page 144, in the middle above the metric tensor, between the parentheses, alpha(dot)=1,2 should be beta(dot) = 1, 2.

Page 153, in Fig 6.3, the rightmost wavefunction change Te^(ips) to Te^(iks).

Exercises:

6.1 continuity equations 6.21 (not 6.3)

6.2 Show that to satisfy $E^2 = p^2 + m^2$ (not $p^2 = m^2$), it is necessary ….

….with $\beta^2 = 1$ (not $m^2$).

## Chapter 7

Fig 7.7 caption should be $\pi^-$ not $\pi^0$

Section 7.3.4 end of first paragraph $\pi^0$ should be $\pi^-$

Table 7.6

Should have s’ not s etc …

$d_L$ should be $d'_L$

$s_L$ should be $s'_L$

$b_L$ should be $b'_L$

Eqn 7.47 there is a missing – sign i.e. this term should be negative.

$\Delta r$ (eqn 7.46) is the sum of the virtual top and Higgs loop corrections to $M_W$ and $M_Z$ as well as the running of the fine structure constant ($\alpha$) from low energy to the value at $M_Z$. The effect of the running of $\alpha$ is given by

\[ \delta r_0=1-\alpha/\alpha(M_Z) \]

Where $\alpha$ is the value of the fine structure constant at low energy and $\alpha(M_Z)$ is the value at the scale $Q^2=M_Z^2$.

The overall sum of these radiative corrections is given by

\[\Delta r = \delta r_0 + \Delta r_{\rm top} + \Delta r_{\rm Higgs} \]

## Chapter 8

Section 8.4.10 3rd line:

“luminosity” should be “integrated luminosity”.

Exercises:

8.1 Add sentence at end of question:

The energy released in the electron capture of the $^{152}$Eu is 840 keV.

8.7 Change “Derive eqn 8.14” to “determine the angular distribution given in eqn 8.14”

8.8

Change

“Estimate the typical energy for the anti-neutrinos” to

The average energy of the anti-neutrinos is approximately 2 MeV.

## Chapter 9

Page 237 eqn 9.12 there should be a factor of (m_e)^2 in the numerator.

On page 244-245: Change equations 9.38 to 9.41:

9.38 In the numerator the $(2p^*)^2$ should read $(p^*)^2$ and in the denominator $(2p^*)^2$ should be $2(p^*)^2$

9.39 The same correction as for eqn 9.38

9.40 The denominator $(2p^*)^2$ should be $2(p^*)^2$

9.41 There should be a factor of -1

Page 248 eqn 9.51 second line: ½ should be ¼.

Page 249 eqn 9.55

F_3^{\nuN} should have additional term: 2 s(x)

F_3^{\overlne{\nu}N} should have additional term: -2 s(x)

Equation 9.67

$d_{1/2}^{-1/2,-1/2}$ should be $d_{-1/2,-1/2}^{1/2}$

Equation 9.69

$d_{1/2}^{1/2,1/2}$ should be $d_{1/2,1/2}^{1/2}$

Page 258 e^{+/-}p → e^- p should be e^{+/-}p → e^{+/-} p

Page 264 eqn 9.33 should be [T_a,T_b]= i f_{abc} T_c

Page 265

Second paragraph

a(r bbar -> r bbar) = -a(rb -> r) = 1/3

should be

a(r bbar -> r bbar) = -a(rb -> rb) = 1/3

## Chapter 10

Section 10.2
"The K_1 lifetime is 600 times the lifetime of the K_2" should be
"The K_2 lifetime is 600 times the lifetime of the K_1",

Page 285, Figure caption 10.3. Add sentence at the end: The data point at the largest value of t/\tau covers the range 5<t/tau<20.

Page 300, equation 10.41: the "–" sign in the denominator should be a "+"

Page 302, cos{\theta_C}=n\beta should be cos{\theta_C}=1/(n\beta)

Page 302 Caption fig 10.15 v >1/n should be \beta>1/n

Page 326 section 11.5.2.

It is known that \Delta m_{12}^2 approx … At this stage all the \Delta m^2 should be absolute values |\Delta m^2|.

Page 330

"B-L" should be "B+L"

Exercises:

10.5 The question states that the tree diagram for the $B_s$ decay is $V_{ub}^{*} V_{us}$ which should be corrected to $V_{ub}^{*} V_{ud}$ .

## Chapter 11

Exercises:

11.7 The question quotes a value for the electron density at the centre of the sun of $N(r) \approx 610^{31} m^{-3}$ The value should be $N(r) \approx 310^{31} m^{-3}$

## Index

Add isospin, p 119

SNO should be Sudbury Neutrino Observatory

## Improvements and Clarifications

The following list does not refer to errors but instead attempts to clear up ambiguities and give clearer explanations.

## Chapter 2

P 19. “However, applying C to the final state has no effect:”

Add margin note:

Applying charge conjugation to a single neutral pion gives $C|\pi^0>=|\pi^0>$, therefore applying the charge conjugation operator to two neutral pions give s a factor of one. Note that this decay mode is also forbidden by Bose-Einstein symmetry: the two pions must be in an L=1 state to conserve angular momentum but this would require the wave function to be anti-symmetric with respect to exchange of identical bosons.

P 24. “Consider the time variation of $U_r$”

Add margin note

Here we explicitly assume that the non-relativistic Schrödinger equation is valid. The resulting conservation law is therefore only valid in the non-relativistic limit. The relativistic case requires the use of the Dirac equation and this will be discussed in chapter 6.

P 51

Add margin note at start of 3.1.3.

In this subsection we will work in SI units.

Fig caption 3.3. should be

The child accelerates the roundabout by only pushing at the correct phase

P 86 “emit an electron by the photoelectric effect” \mnote this is called a photoelectron.

P 94 mid-bandgap states. … in states between the valence and conduction bands (called mid-bandgap states).

## Chapter 7

P. 185, eqn 7.2 uses a simplified expression for the W propagator which is valid for $q^2 << M_W^2$. Therefore to be consistent, the propagator should be simply $1/M^2_W$.

P. 242, eqn 9.32 is only valid in the lab frame.

P. 279 section 10.2

For the $\pi^+\pi^-$ final state, the initial state and final state particles all have S=0. Therefore by conservation of angular momentum, we must have no orbital angular momentum i.e. L=0.