

Errata for Quantum Mechanics

by Ernest Abers

Minor Errata and Cosmetic Corrections as of September 30, 2008 (1st and 2nd printings)

Chapter I

- Page 10, First line of text, replace “vectors” with “vector”:

Examples of vector observables are \mathbf{r} , \mathbf{p} , and \mathbf{L} .

[Thanks to E. Angle, 12/06/2006]

- Page 1, line 3: Change “observables or” to “observables are or”:

The superposition principle and the probability interpretation determine the mathematical framework of quantum mechanics. But, like Newton’s three laws of classical mechanics, these two ideas do not tell us what the observables are or how they

[Thanks to D. Auerbach, 10/12/2004]

- Page 5, top line: Replace “functional” with “function.”

thermodynamics. Think of L as a function with p instead of q as one of the

[Thanks to J. May, 10/11/2004]

- Page 6, just above Equation (1.31): Replace “one” by “once”

Differentiate once more

[Thanks to J. Schilling, 1/11/2005]

- Page 6, Equation (1.33): In the second line replace the outer parentheses with brackets, and the inner parentheses with bigger ones:

$$= q \left[E_k + \left(\frac{\mathbf{v}}{c} \times \mathbf{B} \right)_k \right] \quad (1.33)$$

[Thanks to E. Angle, 11/22/2006]

- Page 6, next to last line: Delete the repeated phrase “for isolated systems”:

For isolated physical systems, these transformations are all symmetries in the sense that when the coordinates undergo these transformations the form of the physical laws is unchanged.

[Thanks to J. May, 10/11/2004]

- Page 9, just above Equation (1.36), delete the period:

Rotations about the z -axis have the form

[Thanks to E. Angle, 12/06/2006]

- Page 9, Equation (1.37): Change 1 to I :

$$\bar{R}(\hat{n}_z, \epsilon) = I + \begin{pmatrix} 0 & -\epsilon & 0 \\ \epsilon & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} \quad (1.37)$$

[10/06/2004]

- Page 9, footnote 6: Replace $R(\theta, \hat{n})$ by $R(\hat{n}, \theta)$ twice:

⁶I reserve the notation $\bar{R}(\hat{n}, \theta)$ for these real 3×3 matrices, to distinguish them from the abstract operation $R(\hat{n}, \theta)$ that appears in Tables 1.1 and 1.2.

[Thanks to E. Hemsing, 10/13/2004]

- Page 10, just above Equation (1.44): insert “are” before “components”:

Any three observables V_i are components of a **vector**

[Thanks to J.Schilling, 1/11/2005]

- Page 15, Problem 1.2, part (d): Insert “ m ,” after K .

Compute \mathbf{A}^2 in terms of \mathbf{L}^2 , K , m , and the energy E .

[Thanks to J. May, 10/13/2004]

- Page 15, Problem 1.2, Part (e): In the next to last line, change “ $\epsilon \leq 1$ ” to “ $\epsilon < 1$ ”:

where E is the total energy, and for a closed orbit, $E < 0$, $\epsilon < 1$.

[Thanks to Y. Wang, 10/19/2005]

- Page 17, Problem 1.6, part (b), last line: Change “or” to “of”:

in terms of the components of \mathbf{A} (\mathbf{L} is still the total angular momentum).

[Thanks to D. Auerbach, 10/12/2004]

- Page 17, Problem 1.7, part (b), note: Delete “last.”

Note: This can be done in a page and a half, but it is easy to get lost;

[Thanks to E. Hemsing, 10/13/2004]

Chapter II

- Page 20, Figure 2.2 caption: Delete the space between the first dash and “or”:

Photons—or electrons—pass through two open slits.

[Thanks to E. Angle, 12/10/2006]

- Page 22, line above Equation (2.3): Replace “pseudovector as” with “pseudovectors”:

$\boldsymbol{\mu}$ and \mathbf{s} are both pseudovectors, and parallel to each other:

[Thanks to D. Auerbach, 10/18/2004]

- Page 25. at the end of the note just above Equation (2.8), change “as” to “is”:

A general position vector is

[Thanks to E. Angle, 12/09/2006]

- Page 25, above Equation (2.9): Change “an complex number” to “a complex number”:

In wave mechanics one frequently has to calculate a complex number from two wave functions using a rule like

[Thanks to J. May, 4/11/2005]

- Page 31, Equation (2.52): In the third row of both equations, on the left, change the subscript from 2 to 3:

$$|\alpha\rangle = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \dots \\ \alpha_n \end{pmatrix} \quad |\beta\rangle = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \dots \\ \beta_n \end{pmatrix} \quad (2.52)$$

[Thanks to G. Marcus, 10/17/2006]

- Page 36, Equation (2.85): Replace $|x\rangle$ with $|\psi_x\rangle$. In Equation (2.91), replace \mathbf{r} with $\psi_{\mathbf{r}}$:

$$\int_{x_o}^{x_o+\Delta x} |\langle\psi| \psi_x\rangle|^2 dx \quad (2.85)$$

$$\rho(\mathbf{r}) = |\langle\psi_{\mathbf{r}}| \psi\rangle|^2 \quad (2.91)$$

[10/18/2004]

- Page 36, twice in the paragraph below Equation (2.85), for consistency $\langle\psi| x\rangle$ should read $\langle\psi| \psi_x\rangle$.

$|\langle\psi| \psi_x\rangle|^2$ is a probability density...

[Thanks to G. Marcus, 10/27/2006]

- Page 41, next to last line: Change the second “(2.118)” to “(2.119)”:

This “demonstration” that $K = H$ solves equations (2.118) and (2.119) is not airtight.

[Thanks to E. Hemsing, 5/29/2005]

- Page 42, Equation (2.125b): Change subscript k to i :

$$[q_j, p_i] = i\delta_{ij} \quad (2.125a)$$

[Thanks to J. May, 11/01/2004]

- Page 42, first full paragraph: change “as is classical mechanics” to “as in classical mechanics”:

then the time dependence of the expectation values of the observables is the same as in classical mechanics.

[Thanks to C. Clark, 10/24/2005]

- Page 42, Equation (2.126a), on the right: Change “ ψ ” to “ $|\psi\rangle$ ”:

$$\boxed{i\hbar \frac{d}{dt} |\psi\rangle = H |\psi\rangle} \quad (2.126a)$$

[Thanks to J. May, 4/11/2005]

- Page 43, second line in paragraph headed “**Units**”: Delete the word “equations”:

Why didn’t the dimensions come out right in equation (2.125)?

[Thanks to J. Schilling, 1/11/2005]

- Page 44. Equation (2.130): Change 1.054887 to 1.054572.

$$\boxed{\hbar = 1.054572 \dots \times 10^{-27} \text{ erg-sec}} \quad (2.130)$$

[Thanks to G. Marcus, 10/17/2006]

- Page 46, in the second sentence of the paragraph that contains Equation (2.147): Insert “the” before Hamiltonian:

When the Hamiltonian is indeed independent of time...

[Thanks to C. Clark, 10/24/2005]

- Page 48, line 3: ϕ should be $|\phi\rangle$:

Let $|\phi\rangle = C|\psi\rangle$. Then the rule $\langle \phi | \phi \rangle \geq 0$ becomes

[10/17/2005]

- Page 48, last line: Insert “can be” before “measured”:

For a wave, the uncertainty principle is the limit on the precision to which both its location and frequency can be measured.

[Thanks to C. Clark, 10/24/2005]

- Page 50, just above Equation (2.183): Insert “to” before “first order”:

Comparing the terms on each side to first order in ϵ one obtains

[Thanks to C. Clark, 11/15/2005]

- Page 50, just above Equation (2.187), change “(2.183)” to “(2.181)”

To first order, from equation (2.181)

[Thanks to J. Ma, 10/27/2005]

- Page 50, footnote 13. Delete “the” before “similar”:

This is similar to the technique used in Section 2.4.1 for translations in time.
[Thanks to C. Clark, 10/24/2005]

- Page 52, Equations (2.197), (2.198), and (2.199): Change Ψ to ψ everywhere

$$\langle \psi | x^2 | \psi \rangle = \frac{a}{\sqrt{\pi}} \int_{-\infty}^{\infty} x^2 e^{-a^2 x^2} dx = \frac{1}{2a^2} \quad (2.197)$$

and similarly

$$\langle \psi | p^2 | \psi \rangle = \int_{-\infty}^{\infty} p^2 |\Phi(p)|^2 dp = \frac{1}{2} a^2 \hbar^2 \quad (2.198)$$

so that

$$\langle \psi | x^2 | \psi \rangle \langle \Psi | p^2 | \psi \rangle = \frac{1}{4} \hbar^2 \quad (2.199)$$

[Thanks to E. Angle, 11/22/2006]

- Page 52, last line of subsection 2.7.2: Change “become” to “becomes”:

For a Gaussian (and only for a Gaussian), the “ \geq ” in the uncertainty principle becomes an equality.

[Thanks to C. Clark, 11/15/2005]

- Page 52, third line of section 2.7.3: Change “(2.126b)” to “(2.126a)”:

If the Hamiltonian is $H = p^2/2m + V(x)$, then the general form (2.126a) of Schrödinger’s equation becomes

[Thanks to J. Schilling, 1/11/2005]

- Page 56 Problem 2.3. Change the value of \hbar from 1.054887 to 1.054572:

$$\frac{\hbar}{2\pi} = \hbar = 1.054572 \times 10^{-27} \text{ erg-seconds}$$

[Thanks to A. Forrester, 10/19/2005]

- Page 58: Problem 2.6, part (b): The subscript on the summation symbol should read “ $n = 0$ ”:

$$\bar{R}(\hat{\mathbf{n}}_z, \theta) = \exp(-i\theta \bar{J}_z) = \sum_{n=0}^{\infty} \frac{1}{n!} (-i\theta \bar{J}_z)^n$$

[Thanks to T. Arlen, 10/17/2006]

- Page 59, Problem 2.9, part (d): Delete the space between “*i.e.*” and the comma:

Then transform by direct substitution (*i.e.*, using the chain rule for partial derivatives)

[Thanks to S. A. Smith, 10/28/2005]

Chapter III

- Page 62, second paragraph: This paragraph does not list the sections of chapter 3 in the correct order!
[Thanks to J. Ma, 10/27/2005]

- Page 68, Equation (3.28): The last factor should be “ $\Theta(a - |x|)$ ”:

$$\psi_1^+(x) = \frac{1}{\sqrt{a}} \cos(\pi x/2a) \Theta(a - |x|) \quad (3.28)$$

[Thanks to E. Angle, 12/13/2006]

- Page 69, line below Equation (3.36) change “equation (3.36)” to “equation (3.35)”:

Since the spectrum of H can be found from equation (3.35)

[Thanks to E. Perlmutter, 11/16/2006]

- Page 72, in the third sentence after Equation (3.62), change “be is zero” to “be zero.”

the potential energy was chosen to be zero when $x = 0$

[Thanks to G. Marcus, 11/07/2006]

- Page 75, Equation (3.80): Put an \hbar in front of the left-hand side:

$$\hbar[r_i, L_j] = i\hbar \sum_k \epsilon_{ijk} r_k \quad (3.80)$$

[Thanks to K. Lane, 1/12/2004]

- Page 76, First line in the last paragraph of Section 3.3.2: Change “ \mathcal{L}_z ” to “ L_z ”:

E will depend on the potential $V(r)$; but the spectrum of \mathbf{L}^2 and L_z follows from spherical symmetry alone.

[Thanks to C. Clark, 11/15/2005]

- Page 77, Line above Equation (3.97a): Change “the J_i ” to J_z :

The new combinations have these commutators with J_z and with each other:

[Thanks to J. Ma, 11/14/2005]

- Page 78, Equation (3.104): In the first line delete the extra small closing bracket.

$$\mathbf{J}^2 |j, j\rangle = \left[\frac{1}{2}(J_+ J_- + J_- J_+) + J_z^2 \right] |j, j\rangle = \left[\frac{1}{2}(J_+ J_- - J_- J_+) + J_z^2 \right] |j, j\rangle \quad (3.104)$$

[Thanks to J. Ma, 11/02/2005]

- Page 83, third line: Replace “that” by “than”:

Equation (3.127) is much simpler than equation (3.78): It is an ordinary

[Thanks to J. deGrassie, 11/03/2004]

- Page 83, line 4: Change “possible find” to “possible to find”:

If necessary it is possible

to find a numerical solution.

[Thanks to D. Staszak, 12/15/2004]

- Page 85, line below Equation (3.142b): Change to “Computing (3.142b) is elementary, but it can get tedious (see problem 5.13).”

[Thanks to D. Matlock, 11/04/2004]

- Page 85, in the line below Equation (3.143): “(3.97b)” should be “(3.97a)”:

have the same energy. Why? From equation (3.97a)

[Thanks to D. Staszak, 12/15/2004]

- Page 87, second line: Insert “each” before “other”:

... and they commute with each other. That...

[Thanks to G. Marcus, 11/15/2006]

- Page 89, Equation (3.164): In the first term, in the numerator, “ d ” should be “ d^2 ”:

$$\frac{d^2}{dr^2}u(r) + \left(-\frac{Z^2}{(na)^2} - \frac{l(l+1)}{r^2} + \frac{2Z}{ar} \right) u(r) = 0 \quad (3.164)$$

[Thanks to C. Clark, 11/15/2005]

- Page 96, Problem, 3.14, line 3: Change Mev to MeV:

If the range a is again the pion Compton wavelength (see Problem 3.12), what is the minimum value of V_o (in MeV) for which there is a bound state?

[Thanks to E. Hemsing, 11/03/2004]

- Page 97, Problem 3.14, part (b): Change “Mev” to “MeV”:

(b) What value for V_o is required for the energy of the bound state to be -2.22 MeV?

[Thanks to J. May, 4/11/2005]

Chapter IV

- Page 102, second paragraph, second sentence: Change “rotations or translations” to “rotations and translations”:

This and the next chapter are about symmetry transformations, especially rotations, in some detail. I will show that systems invariant under rotations and trans-

[Thanks to D. Staszak, 11/20/2004]

- Page 107: Footnote 5 should follow the sentence at the beginning of the paragraph that begins “Since they commute...”

Since they commute, all the representation matrices $D(\hat{\mathbf{n}}, \psi)$ about $\hat{\mathbf{n}}$ also can be written in exponential form using a single real parameter.⁵

[Thanks to D. Staszak, 11/20/2004]

- Page 109, Equation (4.31): On the left, and also in the second factor of the second expression, change outer parentheses to brackets:

$$D[\bar{R}(\hat{\mathbf{n}}_x, \psi)\bar{R}(\hat{\mathbf{n}}_y, \psi)] = D[\bar{R}(\hat{\mathbf{n}}_x, \psi)] D[\bar{R}(\hat{\mathbf{n}}_y, \psi)] = e^{-i\psi D(\bar{J}_x)} e^{-i\psi D(\bar{J}_y)} \quad (4.31)$$

[Thanks to J. May, 4/11/2005]

- Page 113, Equation (4.54): The first r should be boldface:

$$\psi(\mathbf{r}) - i\epsilon \sum_i n_i \langle \mathbf{r} | J_i | \psi \rangle = \psi(\mathbf{r}) - \epsilon \sum_{ijk} n_i \epsilon_{ijk} r_j \frac{\partial \psi}{\partial r_k} \quad (4.54)$$

[11/15/2004]

- Page 116, Footnote 9, second line: Change “is” to “in”:

with the rows and columns labeled by m in *decreasing* order,

[Thanks to N. Kugland, 6/10/2006]

- Page 117, Equation (4.78). Replace the second σ_x by σ_z .

$$\sum_i \left(D^{(\frac{1}{2})}(\bar{J}_i) \right)^2 = \frac{1}{4}\sigma_x^2 + \frac{1}{4}\sigma_y^2 + \frac{1}{4}\sigma_z^2 = \frac{3}{4} = \frac{1}{2} \cdot \left(\frac{1}{2} + 1 \right) \quad (4.78)$$

[Thanks to F. O’Shea, 11/23/2005]

- Page 117: The second displayed equation should be numbered in sequence. I have left it as it is, in order not to change the numbering of the following equations.

[12/09/2004]

- Page 123, second line in footnote 14: Inside the last Dirac bracket, the dot should be a comma.

Another common notation is $|j_1, j_2; m_1, m_2\rangle$ and $|j_1, j_2; j, m\rangle$.

[Thanks to J. Champer, 12/07/2004]

- Page 124: In Equations (4.117) and (4.119), there should be commas in the subscripts of all the kets for consistent notation.

$$s_- \left| \phi_{1,1} \right\rangle = \sqrt{s(s+1) - m(m-1)} \left| \phi_{1,0} \right\rangle = \sqrt{2} \left| \phi_{1,0} \right\rangle \quad (4.117)$$

$$\left| \phi_{1,0} \right\rangle = \frac{1}{\sqrt{2}} \left[\left| \psi_{-\frac{1}{2}, \frac{1}{2}} \right\rangle + \left| \psi_{\frac{1}{2}, -\frac{1}{2}} \right\rangle \right] \quad (4.119)$$

[Thanks to J. Champer, 12/07/2004]

- Page 125, Equation (4.126) and 4.129) : A comma is missing in one of the subscripts in each of these two equations:

$$|\phi_{\frac{3}{2}, \frac{1}{2}}\rangle = \frac{1}{\sqrt{3}} \left[\sqrt{2} |\psi_{0, \frac{1}{2}}\rangle + |\psi_{1, -\frac{1}{2}}\rangle \right] \tag{4.126}$$

....

$$|\phi_{\frac{1}{2}, \frac{1}{2}}\rangle = \frac{1}{\sqrt{3}} \left[\sqrt{2} |\psi_{1, -\frac{1}{2}}\rangle - |\psi_{0, \frac{1}{2}}\rangle \right] \tag{4.129}$$

[Thanks to E. Angle and E. Perlmutter, 12/09/2006]

- Page 126, third paragraph, third line: change $1/2f$ to $1/2$:

Unless $l = 0$, there are two states with $m = l - 1/2$. One linear combination will be in the $j = l + 1/2$ ladder. The remaining one must be the top of a new ladder, this time with $j = l - 1/2$. The number of states in these two ladders adds
[Thanks to K. Lane, 1/12/2004]

- Page 128, bottom line: Delete one “can form”:

Three lines of lengths j_1 ,

j_2 , and j can form a triangle.

[Thanks to J. Champer, 12/07/2004]

Chapter V

- Page 139, in table 5.1, change ν_e in the neutron decay line to $\bar{\nu}_e$, and change ν in the π^- decay line to $\bar{\nu}_\mu$.

n	939.5653	$\hbar/2$	885.7	$n \rightarrow p + e^- + \bar{\nu}_e$
....
π^-	139.570	0	2.6×10^{-8}	$\pi^- \rightarrow \mu^- + \bar{\nu}_\mu$

[Thanks to A. Goodhue, 11/28/2005]

Particle Name	Mass (MeV/c ²)	Spin	Lifetime (seconds)	Decay Mode
.....				
ν_e	$< 3 \times 10^{-6}$	$\hbar/2$	∞	
.....				

- Page 139, Table 5.1. Delete the comma after ν_e in the fourth line from the bottom:

[Thanks to Y. Guo, 3/16/2006]

- Page 139, first line of the last paragraph: Change “particle” to “particles”:

What accounts for the huge range of lifetimes among the particles that do decay?
[Thanks to J. May, 4/11/2005]

- Page 139, bottom line of footnote 1, change the second “eV” to “eV²”:

Mass differences from interference experiments (see Section 6.3) are in the range $10^{-5}\text{eV}^2 \leq \Delta m^2 \leq 10^{-3}\text{eV}^2$.

[Thanks to Y. Guo, 1/23/2006]

- Page 142, just below Equation (5.17d), change “5.17a” to “5.17”. And again on Page 143, at the end of the second full paragraph:

The peculiar signs and phases in the definitions (5.16) were chosen so that (5.17) can be summarized.....

...by inserting commutators $[J_{\pm}, V^q]$ and $[J_z, V^q]$ between the states and using the identities(5.17).

[12/31/2004]

- Page 144, in the line below Equation (5.35), change \hbar^2 to \hbar :

$x_i p_j + \hbar L_i s_j$ is also a rank-two Cartesian tensor.

[Thanks to Y. Guo, 1/23/2006]

- Page 145, in the paragraph above Equation (5.39) delete “symmetry property”. Later in the same paragraph delete “using the orthogonality of the matrices R ”. In the fourth line from the bottom, replace $T_{ij} - T_{ji}$ with $T_{jk} - T_{kj}$:

A symmetric or antisymmetric tensor preserves that property under rotations. For instance, if $T_{ij} = \pm T_{ji}$, then it is simple to show (Problem 5.3) that a fact made explicit by writing $V_i = \sum_{jk} \epsilon_{ijk} (T_{jk} - T_{kj})$.

[Thanks to Y. Guo, 1/23/2006]

- Page 148, last line above the footnote. Replace T_{κ}^q with $\langle \alpha', j', m' | T_{\kappa}^q | \alpha, j, m \rangle$:

Therefore, $\langle \alpha', j', m' | T_{\kappa}^q | \alpha, j, m \rangle = 0$ unless $m' = m + q$.

[Thanks to Y. Guo, 1/23/2006]

- Page 149, on the line just below Equation (5.58): Change κ to q . And in Equation (5.61) for consistency with the notation elsewhere, the subscripts should precede (\bar{R}) :

and that the proportionality constant is *independent* of m' , m , and q .

[Thanks to Y. Guo, 1/23/2006]

- Page 150, Equation (5.64): For consistency with the notation elsewhere, the subscripts should precede (\bar{R}) :

$$R(\bar{R})|\alpha, j_1, m_1, j_2, m_2\rangle = \sum_{m'_1, m'_2} |\alpha, j_1, m'_1, j_2, m'_2\rangle D_{m'_1 m_1}^{(j_1)}(\bar{R}) D_{m'_2 m_2}^{(j_2)}(\bar{R}) \quad (5.64)$$

[Thanks to Y. Guo, 1/23/2006]

- Page 158, fifth paragraph, sixth line, delete one occurrence of the word “systems”:

There is a general rule, arbitrary in nonrelativistic quantum mechanics, that all half-integral spin systems are fermions and all integral spin systems are bosons.

[Thanks to Y. Guo, 3/16/2006]

- Page 158, Equation (5.112): Insert a comma between j_1 and m_1 :

$$|\psi\rangle = |E_1, l_1, j_1, m_1, E_1, l_1, j_1, m_1\rangle \quad (5.112)$$

[Thanks to C. Clark, 3/17/2006]

- Page 161, Equation (5.123): Divide the exponent by \hbar :

$$U(t_f, t_i) = e^{-iH(t_f - t_i)/\hbar} \quad (5.123)$$

[Thanks to K. Lane, 1/12/2004]

Chapter VI

- Page 171, Section 6.1.1, Second paragraph, fourth line: Replace “indicate” with “indicates”

dimensional analysis only indicates...

[Thanks to E. Angle, 3/27/2007]

- Page 171, Last paragraph, second line: Insert a space between “volt” and “(eV)”:

If you need the security of imagining that our equations are written with some underlying unit in mind, take that unit to be the electron volt (eV), the magnitude of the energy acquired by an electron moving through a potential difference of one volt...

[1/09/2006]

- Page 172, Equation (6.6): “ $\mathbf{A}'(\mathbf{r})$ ” should read “ $\mathbf{A}'(\mathbf{r})$ ”:

$$\frac{1}{2m} [-i\nabla + e\mathbf{A}'(\mathbf{r})]^2 e^{-ie\Lambda(\mathbf{r})}\psi(\mathbf{r}) = Ee^{-ie\Lambda(\mathbf{r})}\psi(\mathbf{r}) \quad (6.6)$$

[1/09/2006]

- Page 177, Equation (6.43): The first μ should be in boldface:

$$\boldsymbol{\mu} = -\mu_B(\mathbf{L} + 2\mathbf{s}) = -\mu_B(\mathbf{L} + \boldsymbol{\sigma}) \quad (6.43)$$

[Thanks to E. Perlmutter, 2/01/2007]

- Page 179, Equation (6.48): Enclose “ ρP_a ” in parentheses:

$$\frac{1}{N} \sum_i |\langle \psi_i | \phi_a \rangle|^2 = \text{Tr} (\rho P_a) \quad (6.48)$$

[Thanks to Y. Guo, 1/24/2006]

- Page 183, next-to-last line of the top paragraph, change “What it” to “What is”:

What is the probability for finding the electron in the upper state at a later time?

[Thanks to J. May, 4/11/2005]

- Page 183, second line below Equation (6.84): Change “is has” to “has”; Just above Equation (6.87) change “are” to “satisfy”; and in Equation (6.87), after the first equals sign, change \sum_k to \sum_{jk} :

In the rotating frame \mathbf{H}' has constant components:

Therefore the components of \mathbf{P} in the rotating frame satisfy

$$\frac{d}{dt} [\mathbf{P} \cdot \hat{\mathbf{n}}'_i(t)] = \sum_{jk} \epsilon_{ijk} H'_j P'_k - \sum_k \epsilon_{ijk} \omega_j P'_k \quad (6.87)$$

[1/15/2005]

- Page 183, Equation (6.87): The subscript in the last term should be jk :

$$\frac{d}{dt} [\mathbf{P} \cdot \hat{\mathbf{n}}'_i(t)] = \sum_{jk} \epsilon_{ijk} H'_j P'_k - \sum_{jk} \epsilon_{ijk} \omega_j P'_k \quad (6.87)$$

[Thanks to Y. Guo, 1/23/2006]

- Page 186, third paragraph in Section 6.3.2, end of first sentence: Change “types of neutrino” to “neutrino types” and add a space at the end of the sentence.

To keep the problem simple, I will imagine there are just two neutrino types. This is enough to exhibit the essential features of what is

[Thanks to E Osoba and L. Fredrickson, 1/24/2005]

- Page 187, just above Equation (6.103): Change $|\mu_\tau\rangle$ to $|\nu_\tau\rangle$:

In the basis $|\nu_\mu\rangle$ and $|\nu_\tau\rangle$ of states with definite interaction properties the

[Thanks to D. Matlock, 1/24/2005]

- Page 189, at the end of the first paragraph, add a period.

all the ν_e type and their energies are a few MeV.

[1/27/2005]

- Page 195, Footnote 14: "Apsect" should be "Aspect":

See Aspect, Grangier, and Roger [11,12]...
[Thanks to E. Perlmutter, 2/01/2007]

- Page 199, Problem 6.7, First line of part (a): Delete the second "also":

First let there also be a small constant magnetic field along the x -axis
[Thanks to A. Forrester, 2/08/2006]

- Page 199, Problem 6.7, part (b): In the first line, change "also" to "instead", and in the second line change "the magnetic field" to "the total magnetic field." Then in the equation on the right-hand side change " $\mathbf{B} = \mathbf{B}_1$ " to " $\mathbf{B} = B_o \hat{\mathbf{n}}_z + B_1$ ":

Now let there be a circularly polarized electromagnetic wave instead, such that the total magnetic field at the location of the electron is

$$\mathbf{B} = B_o \hat{\mathbf{n}}_z + B_1 (\hat{\mathbf{n}}_x \cos \omega t + \hat{\mathbf{n}}_y \sin \omega t)$$

[1/23/2005]

Chapter VII

- Page 203, just above Equation (7.7): Change "is" to "in":

H'_{mn} are the matrix elements of H' in the $|\psi_n^o\rangle$ basis:
[Thanks to A. Young, 2/08/2005]

- Page 203, Equation (7.8): In the first line change E_o^n to E_n^o (twice):

$$\begin{aligned} (H - E_n^o + E_n^o - H_o) |\psi_n\rangle &= H' |\psi_n\rangle \\ (H_o - E_n^o) |\psi_n\rangle &= (\Delta_n - H') |\psi_n\rangle \end{aligned} \tag{7.8}$$

[Thanks to K. Lane, 3/19/2004]

- Page 203. in the line below Equation (7.9), delete one "i" in "satisfies":

The proof that equation (7.9) satisfies equation (7.8) is brief:
[Thanks to N. Kugland, 2/13/2006]

- Page 204, Equation (7.16), delete the + sign and the dots at the end of the equation.:

$$\Delta_n^1 + \Delta_n^2 = H'_{nn} - \sum_{m \neq n} \frac{|H'_{mn}|^2}{E_m^o - E_n^o} \tag{7.16}$$

[Thanks to A. Forrester, 2/01/2006]

- Page 205, second bulleted paragraph, seventh line: Change “so” to “but”:

Two states in one of these ladders will have the same unperturbed energy, but we
[Thanks to K. Lane, 3/19/2004]

- Page 206, below Equation (7.26), replace $\lambda/m\omega$ with $\lambda/m\omega^2$:

Expand ω' in powers of $\lambda/m\omega^2$:
[Thanks to J. Wright, 2/07/2006]

- Page 207, in the second line of the paragraph that begins “The way to get around...”:
Change “to completely” to “to be completely”:

H' does not have to be completely diagonal.
[Thanks to J. May, 4/11/2005]

- Page 208, Equation (7.38), the first and last terms replace \mp with \pm :

$$\pm\Delta = \langle\psi_{\pm}|H'|\psi_{\pm}\rangle = \pm eE\langle 210|z|200\rangle \quad (7.38)$$

[Thanks to Y. Guo, 3/16/2006]

- Page 210, Equation (7.47): The lower limit on the last sum in the first line should be 2, not 1.

$$\Delta^{(2)} \geq e^2\mathbf{E}^2 \sum_{n=2}^{\infty} \frac{|\langle n10|z|100\rangle|^2}{E_1 - E_2} = \frac{e^2\mathbf{E}^2}{E_1 - E_2} \sum_{n=2}^{\infty} |\langle n10|z|100\rangle|^2 \quad (7.27)$$

[Thanks to X. Xiao, 3/13/2006]

- Pg 210, second line of “Exact Solution,” there should be a space after footnote 2. Since the typesetter doesn’t like to do this, move the footnote to the end of the paragraph:

Amazingly, it is possible to sum the series in (7.45) and compute the polarizability exactly. I cannot resist presenting this result here briefly, even though the method is not generalizable to a very wide class of problems.²

[Thanks to J. Champer, 2/16/2005]

- Page 210, Footnote 3: Replace “(7.19)” with “(7.20)”:

We also need the normalization condition (7.20), which here reads
[Thanks to Y. Guo, 3/16/2006]

- Page 212, fifth line from the bottom: Change the period after \mathbf{p}^2 to a comma:

\mathbf{r}^2 , \mathbf{p}^2 , \mathbf{L}^2 , and $\mathbf{L} \cdot \mathbf{s}$.

[Thanks to E. Perlmutter, 2/01/2007]

- Page 213, line 3: Delete “is”:

The magnetic field of a point charge q moving with velocity \mathbf{u} can be obtained from the Biot-Savart law.

[Thanks to D. Stazsak, 2/25/2005]

- Page 214, Equations (7.69) and (7.70): Change the subscript “3” to “D”:

$$H_D = -\frac{1}{8m^2} \nabla^2 V(r) \quad (7.69)$$

$$E_D = \frac{\alpha^4 m}{2n^3} \delta_{l0} \quad (7.70)$$

[Thanks to K. Lane, 3/19/2004]

- Page 215: In the top line delete “for any l ”:

Therefore, we can write the sum of the spin-orbit energy...

[Thanks to J. May, 4/11/2005]

- Page 218: Equation (7.89) should be three equation numbers:

$$2S_{\frac{1}{2}} : \quad E = -\frac{\alpha^2 m}{8} - \frac{5\alpha^4 m}{128} + 2m_j \mu_B B \quad (7.89a)$$

$$2P_{\frac{1}{2}} : \quad E = -\frac{\alpha^2 m}{8} - \frac{5\alpha^4 m}{128} + \frac{2}{3} m_j \mu_B B \quad (7.89b)$$

$$2P_{\frac{3}{2}} : \quad E = -\frac{\alpha^2 m}{8} - \frac{\alpha^4 m}{128} + \frac{4}{3} m_j \mu_B B \quad (7.89c)$$

[Thanks to J. Champer, 2/28/2005]

- Page 218, in the second paragraph of subsection 7.3.6: Replace “ μ_p ” with “ μ_N ”:

Its gyromagnetic ratio (measured, for example, in nuclear magnetic resonance experiments) is about 2×2.793 , and $\mu_N = e/2M$.

[Thanks to L. Fredrickson, 2/07/2005]

- Page 219, Equation (7.95): The first “ s_p ” should be boldface:

$$= \frac{ge}{2m} \frac{g_p e}{2M} \left[(\mathbf{s}_p \cdot \nabla) (\mathbf{s} \cdot \nabla) \frac{1}{r} - \mathbf{s}_p \cdot \mathbf{s} \nabla^2 \frac{1}{r} \right] = \frac{gg_p \alpha}{4mM} \sum_{ij} s_{ei} s_{pj} T_{ij}(\mathbf{r}) \quad (7.95)$$

[Thanks to E. Perlmutter, 2/01/2007]

- Page 220, Equation (7.105): In the first line, omit “ $2\Delta_{HFS}$ ”. In the second line change “= 5.85009” to “ ≈ 5.89 ”:

$$\Delta = \frac{2}{3} \times \frac{1}{137.036^4} \times \frac{1}{1836} \times 2 \times 2 \times 2.78 \times 511,000 \text{ eV} \quad (7.105)$$

$$\approx 5.9 \times 10^{-6} \text{ eV}$$

[Thanks to D. Matlock, 7/30/2005]

- Page 222, at the end of the second complete paragraph in Subsection 7.4.2, "ev" should be eV:

the Coulomb potential of a single proton, about -13.6 eV.

[Thanks to E. Perlmutter, 2/01/2007]

- Page 222, Table 7.1: The table should include a third column, identical to the third column in Table 7.2.
[3/16/2006]

	Zero Order	Experiment	Single Electron
H ⁻	-27.21	-14.35	-13.61
He	-108.85	-78.99	-54.43
Li ⁺	-244.90	-198.1	-122.45

- Page 224, bottom line: Replace " $R(a, r)$ " by " $R(a; r)$ ":

$$\langle \mathbf{r} | \psi(a) \rangle = \psi(a; \mathbf{r}) = R(a; r) Y_0^0(\theta, \phi) \quad (7.125)$$

[2/09/2005]

- Page 225, Equation (7.128), in the last expression, ω^3 should be ω^2 :

$$\langle \psi(a) | V | \psi(a) \rangle = \frac{m\omega^2}{2} \int_0^\infty R(a; r)^2 r^4 dr = \frac{3}{2} m\omega^2 a^2 \quad (7.128)$$

[Thanks to N. Kugland, 2/01/2006]

- Page 226. Equation (7.133): Delete the subscript "i" (four times):

$$\int \psi_{100}(\mathbf{r}) \left(\frac{p^2}{2m} - \frac{\sigma e^2}{r} \right) \psi_{100}(\mathbf{r}) d^3r = E_1^o(\sigma) = \sigma^2 E_1^o \quad (7.133)$$

[Thanks to K. Lane, 3/19/2004]

- Page 227, Equation (7.139): \mathbf{r}_1 and \mathbf{r}_2 should always be enclosed in parentheses.

$$\psi(\mathbf{r}_1, \mathbf{r}_2) = \frac{1}{\sqrt{2}} \left[\psi_{nlm}(\mathbf{r}_1) \psi_{n'l'm'}(\mathbf{r}_2) \pm \psi_{nlm}(\mathbf{r}_2) \psi_{n'l'm'}(\mathbf{r}_1) \right] \quad (7.139)$$

[Thanks to A. Goodhue, 2/08/2006]

- Page 227, third line below Equation (7.139), replace "a" with "an":

when both electrons are in an excited state,

[Thanks to Y. Guo, 3/16/2006]

- Page 227, Equation (7.141): Delete the extra “ q ” in the exponent on the far right:

$$\psi_{1s}(\mathbf{r}) = \frac{Z_1^{3/2}}{\sqrt{\pi a^3}} e^{-Z_1 r/a} \quad \text{and} \quad \psi_{2p}(\mathbf{r}) = \frac{1}{2\sqrt{6}} \left(\frac{Z_2}{a} \right)^{\frac{5}{2}} r e^{-Z_2 r/2a} Y_1^m(\theta, \phi) \quad (7.141)$$

[Thanks to Y. Guo, 3/08/2006]

- Page 232, Equation (7.167), the first line should end in $d^n r$:

$$\int \psi_o(\mathbf{r}, \mathbf{R})^* \nabla_i^2 \psi_o(\mathbf{r}, \mathbf{R}) \phi(\mathbf{R}) d^n r \quad (7.167)$$

[Thanks to Y. Guo, 3/08/2006]

- Page 234. Equation (7.186): replace the outer parentheses and brackets by brackets and large braces:

$$\frac{E_{\pm}(R)}{|E_1^o|} = \frac{2a}{R} - 1 - \frac{2a}{1 \pm I} \left\{ \left[\frac{1}{R} - \left(\frac{1}{a} + \frac{1}{R} \right) e^{-2R/a} \right] \pm \left[\left(\frac{1}{a} + \frac{R}{a^2} \right) e^{-R/a} \right] \right\} \quad (7.186)$$

[2/08/2006]

- Page 236. In Equation (7.190) and again in Equation (7.194): replace $\phi(R)$ with $R\phi(R)$:

$$\left[-\frac{1}{M} \left(\frac{d^2}{dR^2} - \frac{l(l+1)}{R^2} \right) + E(R) \right] [R\phi(R)] = E [R\phi(R)] \quad (7.190)$$

.....

$$\left[-\frac{1}{M} \frac{d^2}{dR^2} + \frac{M\omega^2(R - R_o)^2}{4} \right] [R\phi(R)] = E [R\phi(R)] \quad (7.194)$$

[2/08/2006]

- Page 239, Equation (7.213): Put a bracket around “ $\psi(x)^*\psi'(x)$ ”. In the next line, replace “constant” with “constants”:

$$j(x) = \frac{1}{m} \text{Im} [\psi(x)^*\psi'(x)] \quad (7.213)$$

is a constant.²¹ Equate the constants on both sides of the turning point to get

[1/11/2006]

- Page 241, last line in the first complete paragraph: Change (7.203) to (7.219):

the singularity in the Bessel functions will disappear when the transformations that led from equation (7.219) to (7.229) are undone.

[1/15/2006]

- Page 243, second and third sentence of the paragraph beginning “I have taken” should read “There is also a connection formula when $V(x)$ is increasing.....

There is also a connection formula when $V(x)$ is increasing through a turning point $x = a$. Then equation...

[1/11/2006]

- Page 246, Equation (7.262c), replace B with B_3 . Also, the curve in Figure 7.6 is slightly displaced:

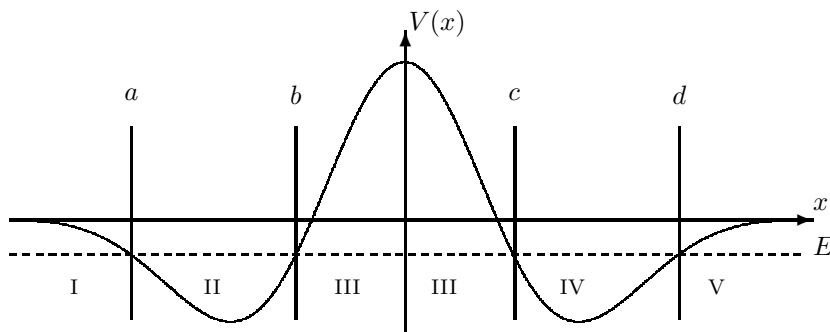


Figure 1: A double well potential illustrating the five separate WKB-approximation regions

.....

$$\psi_{III}(x) \approx \frac{A_3}{\sqrt{\kappa(x)}} \exp \left[- \int_b^x \kappa(x') dx' \right] + \frac{B_3}{\sqrt{\kappa(x)}} \exp \left[\int_b^x \kappa(x') dx' \right] \quad (7.262c)$$

[Thanks to Y. Guo, 2/27/2006]

- Page 251, Problem 7.8, Part (a), third line: Replace “an inhomogeneous” with “a nonconstant”. In the equation in part (c), fix the vertical alignment of the second small left-parenthesis:

Suppose a spin-3/2 nucleus at the origin is placed in a nonconstant electric field whose potential is $V(\mathbf{r})$

.....

$$H' = c \sum_i (s_i)^2 \frac{\partial V(\mathbf{r})}{\partial r_i^2} \Big|_{r=0}$$

[Thanks to D. Matlock, 2/14/2005]

- Page 257, in footnote 29, “eight” should be “seven”:

The numerical values of the three lowest energies, to seven significant figures, are...

[Thanks to Z. Cook, 2/21/2006]

Chapter VIII

- Page 264, the paragraph above Equation (8.3) should begin “A nonrelativistic particle scattering off a potential”:

A nonrelativistic particle scattering off a potential has a wave function...

[Thanks to J. Ma, 2/15/2006]

- Page 265, Equation (8.9): On the left, replace “<” and “>” with angle brackets :

$$\langle \mathbf{k}' | \mathbf{k} \rangle = \delta_3(\mathbf{k}' - \mathbf{k}) \quad (8.9)$$

[Thanks to C. Clark, 3/17/2006]

- Page 266, Equation (8.16), in the last term, the ϕ in the denominator should be squared.

$$\nabla^2 = \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial}{\partial r} \right) + \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial}{\partial \theta} \right) + \frac{1}{r^2 \sin^2 \theta} \frac{\partial^2}{\partial \phi^2} \quad (8.16)$$

[Thanks to J. Ma, 2/15/2006]

- Page 269, Equation(8.27): Change $\psi(r')$ to $\psi(\mathbf{r}')$:

$$\chi(\mathbf{r}) = \int G(\mathbf{r}, \mathbf{r}') U(\mathbf{r}') \psi(\mathbf{r}') d^3 r' \quad (8.27)$$

[2/15/2006]

- Page 270, Equation (8.36), change “ $U(r)$ ” to “ $U(\mathbf{r})$ ”, and similarly in Equation (8.38a):

$$\boxed{f^{(1)}(\theta, \phi) = -\frac{1}{4\pi} \int d^3 r e^{-i\mathbf{k}' \cdot \mathbf{r}} U(\mathbf{r}) e^{i\mathbf{k} \cdot \mathbf{r}} = -2\pi^2 \langle \phi_{\mathbf{k}'} | U(\mathbf{r}) | \phi_{\mathbf{k}} \rangle} \quad (8.36)$$

$$\psi^{(n)}(\mathbf{r}) = \frac{1}{(2\pi)^{\frac{3}{2}}} \left[e^{i\mathbf{k} \cdot \mathbf{r}} - \frac{(2\pi)^{3/2}}{4\pi} \int d^3 r' \frac{e^{ik|\mathbf{r}' - \mathbf{r}|}}{4\pi|\mathbf{r}' - \mathbf{r}|} U(\mathbf{r}') \psi^{(n-1)}(\mathbf{r}') \right] \quad (8.38a)$$

[Thanks to J. May, 4/11/2005]

- Page 270, Equation (8.39): Replace r by r' inside the integral.

$$f^{(1)}(\theta, \phi) = -\frac{1}{4\pi} \int e^{i(\mathbf{k} - \mathbf{k}') \cdot \mathbf{r}'} U(\mathbf{r}') d^3 r' \quad (8.39)$$

[Thanks to M. Gutperle, 5/05/2004]

- Page 272, top line of the first paragraph: Delete the second “idea”:

In the early nineteenth century the wave idea of light was supported by Young’s double-slit interference experiment,

[Thanks to J. May, 4/11/2005]

- Page 272, In twelfth line of the first paragraph, change “that” to “than”. And in Equation (8.50), in the first term, the dot should precede $\hat{\mathbf{n}}$:

Together that sum is greater than the original flux...

$$\text{Im} \int (\psi^* \nabla \psi) \cdot \hat{\mathbf{n}} dS = \text{Im} \int \psi^* \frac{\partial \psi}{\partial r} dS = 0 \quad (8.50)$$

[Thanks to Y. Guo and J. Ma, 3/06/2006]

- Pages 272 and 273, Equations (8.52), (8.54), (8.55), and (8.56): Delete the small parentheses around the fractions:

$$0 = \text{Im} \int \left[\phi^* \frac{\partial \chi}{\partial r} + \chi^* \frac{\partial \phi}{\partial r} + \chi^* \frac{\partial \chi}{\partial r} \right] r^2 d\Omega \quad (8.52)$$

$$\int \chi^* \frac{\partial \chi}{\partial r} r^2 d\Omega \rightarrow \frac{ik}{(2\pi)^3} \int |f(\theta, \phi)|^2 d\Omega = \frac{ik\sigma_{tot}}{(2\pi)^3} \quad (8.54)$$

$$\text{Im} \psi^* \frac{\partial \phi}{\partial r} = -\text{Im} \psi \frac{\partial \phi^*}{\partial r} \quad (8.55)$$

$$\begin{aligned} \frac{k\sigma_{tot}}{(2\pi)^3} &= -\text{Im} \int \left(\phi^* \frac{\partial \chi}{\partial r} + \chi^* \frac{\partial \phi}{\partial r} \right) r^2 d\Omega \\ &= -\text{Im} \int \left(\phi^* \frac{\partial \chi}{\partial r} \right) - \chi \frac{\partial \phi^*}{\partial r} \right) r^2 d\Omega \\ &= -\text{Im} \int \left(\phi^* \frac{\partial \psi}{\partial r} - \psi \frac{\partial \phi^*}{\partial r} \right) r^2 d\Omega \end{aligned} \quad (8.56)$$

[Thanks to E. Angle, 3/27/2007]

- Page 277, Equation (8.80): In the first line, in the numerator of first factor, change $2l + l$ to $2l + 1$:

$$\begin{aligned} A_l \rho^l \frac{2^l l!}{(2l+1)!} &= \frac{2l+1}{2} \sum_n i^n \frac{\rho^n}{n!} \frac{2^n (n!)^2}{(2n)!} \int_{-1}^1 P_n(z) P_l(z) dz \\ &= i^l \frac{\rho^l}{l!} \frac{2^l (l!)^2}{(2l)!} \end{aligned} \quad (8.80)$$

[Thanks to M. Gutperle, 5/18/2004]

- Page 278, third line of the first full paragraph, delete “and is a linear combination of e^{ikr} and e^{-ikr} ”:

approaches a free radial wave function. For large r , the radial function $R_l(r)$ looks like

[Thanks to Y. Guo, 3/06/2006]

- Page 279, first line of the second paragraph: Insert a space before “and”:

Next expand $\psi(\mathbf{r})$ and $\phi(\mathbf{r})$,
[Thanks to J. May, 4/11/2005]

- Page 280, at the end of the penultimate paragraph, delete the extra closing parenthesis. And in the fourth line from the bottom, change “to fall” to “have to fall”:

is substituted for one three-dimensional partial differential equation or integral equation for $\psi(\mathbf{r})$.

.....

So the phase shifts δ_l have to fall off rapidly with increasing l .
[Thanks to Y. Guo, 3/06/2006]

- Page 283. Equation (8.114) in the last factor on the middle line, change r to r' :

$$\rightarrow \sum_l \frac{(2l+1)}{4\pi} P_l(\cos \Theta) C_l \left(-\frac{i(2l-1)!!}{(kr)^{l+1}} \right) \left(\frac{(kr')^l}{(2l+1)!!} \right) \quad (8.114)$$

[Thanks to Y. Guo, 3/16/2006]

- Page 283, just above Equation (8.120) change “phase shift” to “term”:

In particular, near the scattering threshold $k \rightarrow 0$ only the $l = 0$ term survives.
[Thanks to Y. Wang, 3/17/2006]

- Page 284, Equation (8.126) insert a minus sign after the second equals sign:

$$h_1(r) = -\left(\frac{1}{\rho} + \frac{i}{\rho^2}\right)e^{i\rho} = -\frac{1}{\rho^2}(\rho + i)e^{i\rho} \quad (8.126)$$

[Thanks to Y. Guo, 3/16/2006]

- Page 284, Equation (8.126). The brackets on the left should be larger. And in the next equation, replace the outer parentheses with brackets:

$$h_1(r) = -\left(\frac{1}{\rho} + \frac{i}{\rho^2}\right)e^{i\rho} = -\frac{1}{\rho^2}(\rho + i)e^{i\rho} \quad (8.126)$$

$$\delta_1 = -ka + \frac{1}{2} \arctan \left[\frac{2ka}{1 - (ka)^2} \right] = -ka + \arctan(ka) \quad (8.127)$$

[Thanks to E. Angle, 3/27/2007]

- Page 284, Equation (8.127): Delete the extra parenthesis in the denominator:

$$\delta_1 = -ka + \frac{1}{2} \arctan \left(\frac{2ka}{1 - (ka)^2} \right) = -ka + \arctan(ka) \quad (8.127)$$

[Thanks to J. May, 4/11/2005]

- Page 284, Problem 8.1: In the line just following the unnumbered displayed equation, on the right-hand-side of the in-line equation, remove the middle vertical line:

where $\rho(\mathbf{r}) = |\psi_{100}(\mathbf{r})|^2$, the probability distribution of the bound electron.
[Thanks to M. Gutperle, 5/13/2004]

- Page 285, Problem 8.3, at the end of the first paragraph, replace $2\pi/m_\pi$ with $1/m_\pi$:

... and took the range of the potential to be $1/m_\pi$.
[Thanks to A. Goodhue, 3/06/2006]

- Page 287, Reference [3]: Replace the comma after K by a period:

[3] K. GOTTFRIED, *Quantum Mechanics, Volume I*, Benjamin, 1966. See also Appendix D.
[7/21/2004]

Chapter IX

- Page 288, in the subsection heading just below “9.1.2 The Semiclassical Method”: Change “Transistions” to “Transitions”.

[5/11/2004]

- Page 288, just below Equation (9.4): “wherer” should be “where”:

where $\hat{\boldsymbol{\epsilon}}$ is the polarization vector:
[Thanks to D. Staszak, 6/08/2005]

- Page 289, in the paragraph above “**Incoherent Radiation**”: change ω_{ba} to $|\omega_{ba}|$:

outside the frequency region $|\omega - |\omega_{ba}|| \leq 2\pi/t$.
[Thanks to Y. Guo, 5/01/2006]

- Page 291, Equation (9.18): Replace $e^{i\mathbf{k}\cdot\mathbf{r}}$ by $e^{-i\mathbf{k}\cdot\mathbf{r}}$:

$$\langle \psi_b | \hat{\boldsymbol{\epsilon}} \cdot \mathbf{p} e^{-i\mathbf{k}\cdot\mathbf{r}} | \psi_a \rangle \approx -im\hat{\boldsymbol{\epsilon}} \cdot \langle \psi_b | [\mathbf{r}, H_o] | \psi_a \rangle \quad (9.18)$$

[Thanks to Y. Guo, 5/01/2006]

- Page 294, in the text just below Equation (9.30): Change “has an inverse” to “exists”:

Even though the operator $H - \omega$ has no inverse for positive *real* ω , $G(\omega)$ exists for real ω and any finite real ϵ .

[Thanks to K. Lane, 2/18/2004]

- Page 294, in the paragraph beginning “The unperturbed Hamiltonian”, in the second line: Delete “that” before “the matrix elements”:

The unperturbed Hamiltonian H_o is diagonal in the states $|\phi_a\rangle$, and, as in bound-state perturbation theory, the matrix elements of H' between eigenstates of H_o are assumed computable.

[Thanks to J. May, 4/11/2005]

- Page 294: There is no Equation (9.33). Latex just skipped an equation number! I don't really understand how this could have happened, but it is under control.
[7/22/2004]

- Page 295, in the sentence above equation (9.41), change (9.36) to (9.37), and in the sentence above Equation (9.42), change the first (9.40) to (9.39):

and from equation (9.37)

..... From equations (9.39) and (9.40) it also follows that

[Thanks to M. Gutperle, 5/13/2004]

- Page 296, Equation (9.44), delete the summation sign on the right-hand side.

$$= \frac{i}{2\pi} \delta_{ca} \int_{-\infty}^{\infty} e^{-i\omega(t-t_o)} \frac{1}{\omega - \omega_a + i\epsilon} d\omega \quad (9.44)$$

[Thanks to Y. Guo, 5/01/2006]

- Page 297, Equation (9.49), change ω to ω_a :

$$\boxed{|\psi_a\rangle = |\phi_a\rangle + G^o(\omega_a)H'|\psi_a\rangle} \quad (9.49)$$

[Thanks to Y. Guo, 5/02/2006]

- Page 297, Equation (9.51) In the last expression on the first line, change $G^o(\omega)$ to $G^o(\omega_a)$:

$$T(\omega_a)_{ba} = \langle \phi_b | T(\omega_a) | \phi_a \rangle = \langle \phi_b | H' + H'G^o(\omega_a)T(\omega_a) | \phi_a \rangle \quad (9.51)$$

[Thanks to C. Cooper, 6/11/2006]

- Page 298, first paragraph in subsection 9.3.1, change (9.36) to (9.40):

then from equations (9.31) and (9.40)

[Thanks to Y. Guo, 5/02/2006]

- Page 300, Equation (9.67) inside the sine function: Interchange ω_a and ω_b and delete the extra parenthesis on the right:

$$\Gamma = \frac{d}{dt} P_{ba} = 2|T_{ba}(\omega_a)|^2 \frac{\sin [(\omega_b - \omega_a)(t - t_o)]}{\omega_b - \omega_a} \xrightarrow[t_o \rightarrow -\infty]{t \rightarrow \infty} 2\pi |T_{ba}(\omega_a)|^2 \delta(\omega_b - \omega_a) \quad (9.67)$$

[Thanks to E. Hemsing and J. May, 3/07/2005]

- Page 300, in the second line below Equation (9.67), change “use” to “used”:

In the last form I have used the representation

[Thanks to Y. Guo, 5/02/2006]

- Page 301, just before the “Optical Theorem” heading: Add “The relativistically correct forms of Equations (9.71) and (9.72) are obtained replacing m^2 by ω_a^2 ” (This is too long to be fixed in a reprinting).
[Thanks to K. Lane, 2/21/2004]

- Page 302, in the second paragraph of subsection 9.3.4, change “that” to “than”:

spin-orbit interactions are much smaller than the Coulomb forces

[Thanks to Y. Guo, 5/02/2006]

- Page 304, Equation (9.87), on the right-hand side, the “ i ” should be outside the bracket:

$$\langle \mathbf{r}_1, \mathbf{r}_2 | \phi_b \rangle = \phi_b(\mathbf{r}_1, \mathbf{r}_2) = \frac{1}{(2\pi)^3} e^{i(\mathbf{k}'_1 \cdot \mathbf{r}_1 + \mathbf{k}'_2 \cdot \mathbf{r}_2)} \quad (9.87)$$

[Thanks to Y. Guo, 5/03/2006]

- Page 306, third line of paragraph beginning “The simplest example...”, change “Each” to “ H'_{ba} ”:

H'_{ba} must be antisymmetric upon interchanging *all* the electron’s properties,

[Thanks to Y. Guo, 5/03/2006]

- Page 309, Paragraph below Equation (9.112), change “an property” to “a property”:

even though that cannot be a property of the true Γ .

[Thanks to Y. Guo, 5/03/2006]

- Page 312, Equation (9.131), in the last term in the denominator, change ω to ω_b . And in Equation (9.132) change the sign before “Re”:

$$\left. + i\pi \sum_{b \neq a} |H'_{ba}|^2 \delta(\omega_b - \omega_a) + \dots \right]^{-1} \quad (9.131)$$

$$\omega'_a = \omega_a + H'_{aa} - \text{Re} \sum_{b \neq a} |H'_{ba}|^2 \frac{1}{\omega_b - \omega_a} + \dots \quad (9.132)$$

[Thanks to Y. Guo, 5/03/2006]

- Page 314, Equation (9.140): Replace “ \rightarrow ” with “ \sim ”: (for small t one cannot take $T(\omega)_{ba}$ outside the integral as in section 9.3.2)

$$P_{ba}(t) \approx |T_{ba}(\omega_a)|^2 t^2 \quad (9.140)$$

[Thanks to Y. Guo, 5/03/2006]

- Page 315, Equation (9.145): Insert $d\omega$ at the end on the right. And in Equation (9.146), second line, first term on the left, change ω_a to ω'_a

$$= -\frac{1}{2\pi i} H'_{ba} \int_{-\infty}^{\infty} e^{-i\omega t} \frac{1}{\omega - \omega_b + i\epsilon} \frac{1}{\omega - \omega'_a + i\Gamma/2} d\omega \quad (9.145)$$

....

$$\left. -e^{-i\omega_a't} e^{-\Gamma t/2} \frac{1}{\omega_b - \omega_a' + i(\Gamma/2 + \epsilon)} \right] = H'_{ba} e^{-i\omega_b t} \frac{1 - e^{i(\omega_b - \omega_a')t} e^{-\Gamma t/2}}{\omega_b - \omega_a' + i\Gamma/2} \quad (9.146)$$

[Thanks to J. Ma, 3/13/2006]

- Page 315, in the line immediately below Figure 9.6, change ω_a to ω_b :

Close the contour in the lower half plane, picking up the poles at $\omega_b - i\epsilon$ and at $\omega_a' - i\Gamma/2$:

[Thanks to Y. Guo, 5/03/2006]

- Page 315, Equation (9.148): Change “ $absH'_{ba}$ ” to “ $|H'_{ba}|$ ”:

$$\frac{d}{dt} |a_{ba}(t)|^2 \rightarrow |H'_{ba}|^2 \frac{2(\omega_a' - \omega_b) \sin(\omega_a' - \omega_b)t}{(\omega_a' - \omega_b)^2 + \Gamma^2/4} \quad (9.148)$$

[Thanks to M. Gutperle, 5/18/2004]

- Page 317, Problem 9.3: Delete the extra vertical line in $|\langle \psi_+ | \psi(t) \rangle|^2$:

Use the first-order time-dependent perturbation formalism of Section 9.1.1 to compute $|\langle \psi_+ | \psi(t) \rangle|^2$,

[Thanks to J. May, 4/11/2005]

- Page 319, Problem 9.7, part (b): Change “masses of the two decay particles” to “masses of the three particles.”:

What is the magnitude p of the momentum of either particle in that frame, in terms of the masses of the three particles?

[4/25/2005]

- Page 319, Problem 9.7, Part (c), first line: Replace \mathbf{p}_λ with \mathbf{p}_Λ :

The initial state contains a Λ with momentum \mathbf{p}_Λ and spin index m_Λ .

[Thanks to J. May, 6/14/2005]

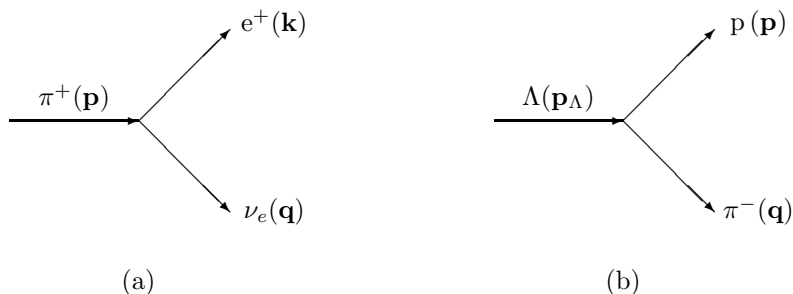
- Page 320, diagram (a): The neutrino should not have a positive charge.

[Thanks to D. Staszak, 6/11/2005]

- Page 321, Problem 9.8, sixth line on the page: insert “angular” before “momentum of the neutrino”:

The angular momentum of the positron is fixed by the angular momentum of the neutrino.

[Thanks to A. Tableman, 5/17/2006]



- Page 321, Problem 9.8, Part (a), in the second line of the first equation in the “hint”: The superscript 2 should be to the right of the large vertical bar.

$$\times |\langle \pi^o(\text{at rest}); \mathbf{k}; \mathbf{q} | H_W | \pi^+(\text{at rest}) \rangle|^2 d^3k d^3q$$

[Thanks to E. Hemsing, 4/18/2005]

- Page 321, Problem 9.8, Part (c). Change “proportional to m_e ” to “for small m_e ”:

Can you estimate the error for small m_e ?

[5/03/2006]

- Page 321, Problem 9.8, second line of Part (d): Replace “that” with “than”:

If you did the computation correctly, you found a rate for π^+ β -decay orders of magnitude smaller than the rate for the two-body decay...

[Thanks to D. Matlock, 5/16/2005]

- Page 322, Problem 9.9, in the second line, delete the space after π^+ , and in the fifth line of part (a), change “that” to “than”:

is similar to the β -decay of a π^+ .

.....

(much smaller than m_e)

[Thanks to A. Tableman, 5/17/2006]

- Page 322, Problem 9.9, second paragraph: In the last sentence, change “positron and neutrino” to “electron and antineutrino”:

\mathbf{k} and \mathbf{q} are the final state electron and antineutrino momenta.

[Thanks to L. Fredrickson, 5/10/2005]

- Page 323, Problem 9.10, needs to be more explicit: In Part (a), replace the first four lines by

Calculate the quantity

$$\frac{\Gamma_{\text{up}} - \Gamma_{\text{down}}}{\Gamma_{\text{up}} + \Gamma_{\text{down}}}$$

It would be zero if parity were conserved in Λ decay (why?).

.....

Replace Part (b) with

For an arbitrary initial Λ spin state, write a formula for the expectation value $\langle \sigma_{\hat{n}} \rangle / 2$ of the components of the proton spin as a function of the proton direction and the two-component spin factor χ_{Λ} in the Λ wave function.

...

In Part(c), replace “ the expectation value of the proton spin” with “ $\langle \sigma_{\hat{n}} \rangle$ ”, and include the boldface subscript \hat{n} in the displayed formula:

$$F(\hat{n})\langle \sigma_{\hat{n}} \rangle = (\alpha + \mathbf{P} \cdot \hat{n}) \hat{n} + \beta \mathbf{P} \times \hat{n} + \gamma \hat{n} \times (\mathbf{P} \times \hat{n})$$

[6/18/2006]

Chapter X

- Page 324, Equation (10.3): Replace t by t_a (twice):

$$t_o = t_a \quad t_{N+1} = t_a + (N + 1)\epsilon = t_b \quad t_n = t_a + n\epsilon \quad (10.3)$$

[5/30/2007]

- Page 325, Equation (10.12), in the second and fourth expressions: “ dp ” should be outside the brackets:

$$\begin{aligned} \langle q_n | e^{-iH(t_n - t_{n-1})} | q_{n-1} \rangle &= \frac{1}{2\pi} \int e^{ip(q_n - q_{n-1})} [1 - i\epsilon H(p, q_n)] dp \\ &\approx \frac{1}{2\pi} \int e^{ip(q_n - q_{n-1})} e^{-i\epsilon H(p, q_n)} dp = \frac{1}{2\pi} \int \exp(i\epsilon [p\dot{q}_n - H(p, q_n)]) dp \end{aligned} \quad (10.12)$$

[Thanks to N. Robles, 1/22/2005]

- Page 325, Equation (10.12), in the exponent of the first term on the second line, change q_{n+1} to q_{n-1} :

$$\approx \frac{1}{2\pi} \int e^{ip(q_n - q_{n-1})} e^{-i\epsilon H(p, q_n)} dp = \frac{1}{2\pi} \int \exp(i\epsilon [p\dot{q}_n - H(p, q_n)]) dp \quad (10.12)$$

[Thanks to Y. Guo, 5/22/2006]

- Page 326, just below Equation (10.15), there is a closing bracket missing before “when”. Then in the paragraph beginning “The derivation of the path integral”, in the fourth line, delete the first “with”. And finally, in Equation (10.17), on the left, inside the exponential, put an ϵ before $p_n^2/2m$:

Inside the integral you have to remember the factor $\Theta(t_b - t_a) \exp[-\eta(t_b - t_a)]$ when needed.....

The commutators generate new terms with fewer factors...

$$\int dp_n \exp\left(i\epsilon p_n \dot{q}_n - i\epsilon \frac{p_n^2}{2m}\right) = \sqrt{\frac{2m\pi}{i\epsilon}} \exp\left(\frac{i\epsilon m \dot{q}_n^2}{2}\right) \quad (10.17)$$

[Thanks to D. Staszac, 11/21/2005]

- Page 327, Equation (10.23): “ dt ” is missing in the last integral:

$$S[q] = S[q_o] + \frac{1}{2} \int_{t_a}^{t_b} \frac{\partial^2 L(\dot{q}_o)}{\partial \dot{q}^2} \delta \dot{q}(t)^2 dt \quad (10.23)$$

[Thanks to N. Robles, 1/30/2005]

- Page 328, Equation (10.28), in the first line change \dot{q} to \dot{q}_n :

$$I_N = \int \prod_{n=1}^N dq_n \exp\left(i\epsilon \sum_{n=1}^{N+1} \frac{m \dot{q}_n^2}{2}\right) \quad (10.28)$$

[Thanks to Y. Guo, 5/22/2006]

- Page 333, Equation (10.66): At the end, dw should be inside the parenthesis.

$$K_E(q_b, T; q_a, 0) = \sum_n \psi_n(q_a) \psi_n(q_b)^* e^{-E_n T} = \int \mathcal{D}q \exp\left(-\int L_E[q(w)] dw\right) \quad (10.66)$$

[Thanks to Y. Guo, 5/22/2006]

- Page 335, Equation (10.77) in the line that begins with “ \times ”: Insert an integral sign before the large product symbol:

$$\times \int dq_k V(q_k) \left(\frac{m}{2\pi i\epsilon}\right)^{(N+1-k)/2} \int \prod_{j=k+1}^N dq_j \exp\left[i\epsilon \sum_{n=k+1}^N \left(\frac{m \dot{q}_n^2}{2}\right)\right]$$

[Thanks to N. Robles, 1/30/2005]

- Page 336, in the paragraph below Equation (10.81), sixth line, should read ”freely from $q_a, 0$ to q_b, t_b . Or it can propagate from q_1, t_1 to q_b, t_b ”:

The particle may propagate freely from $q_a, 0$ to q_b, t_b . Or it can propagate from q_1, t_1 to q_b, t_b ,

[Thanks to Y. Guo, 5/22/2006]

- Page 338, first paragraph of section 10.2.3, in the third line, change z to x :

There are two small holes in the plane, on the x axis at $x = \pm d/2$,

[Thanks to Y. Guo, 5/22/2006]

- Page 339, Equation (10.95) change t_z to t_a .

$$\psi(\mathbf{r}_b, t_b) = \int d^3r_a \int \mathcal{D}\mathbf{r} K(\mathbf{r}_b, t_b; \mathbf{r}_a, t_a) e^{iS_0} \psi(\mathbf{r}_a) \quad (10.95)$$

[Thanks to Y. Guo, 5/22/2006]

- Page 343, Equation (10.115): the symbols $\psi_{\pm}(\phi)$ should be enclosed in Dirac brackets.

$$|\psi_+(\phi)\rangle = \begin{pmatrix} \cos \frac{\theta}{2} \\ \sin \frac{\theta}{2} e^{i\phi} \end{pmatrix} \quad \text{and} \quad |\psi_-(\phi)\rangle = \begin{pmatrix} \sin \frac{\theta}{2} \\ -\cos \frac{\theta}{2} e^{i\phi} \end{pmatrix} \quad (10.115)$$

[6/07/2006]

- Page 344, Equation (10.124): insert an i before the integral sign on the second line:

$$= i \int_0^{2\pi} \langle \psi_-(\phi) | \psi'_-(\phi) \rangle d\phi = -\pi(1 + \cos \theta) \quad (10.124)$$

[Thanks to Y. Guo, 5/23/2006]

- Page 345, in Equation (10.130), delete the i , and in Equation (10.131), replace \mathbf{R} with $d\mathbf{R}$:

$$\gamma(t) = \int_{R(0)}^{R(t)} \mathbf{A}(\mathbf{R}) \cdot d\mathbf{R} \quad (10.130)$$

.....

$$\gamma(t) = \int_C \mathbf{A}(\mathbf{R}) \cdot d\mathbf{R} = \int \nabla \times \mathbf{A} \cdot d\mathbf{S} \quad (10.131)$$

[Thanks to Y. Guo and J. Ma, 5/23/2006]

- Page 355, Reference [14]: Change Tycho to Tycko, here and in the index.

[14] R. TYCKO, Phys. Rev. Letters **58** (1987) 2281.

[Thanks to M. Gutperle, 4/15/2004]

Chapter XI

- Page 358, Equation (11.13a): The letter t and the superscript 2 should not be boldface.:

$$\ddot{\mathbf{Q}}(\mathbf{k}, t) + \omega^2 \mathbf{Q}(\mathbf{k}, t) = 0 \quad (11.13a)$$

[Thanks to J. May, 6/14/2005]

- Page 359: In Equation (11.21), change “ $\hat{\boldsymbol{\varepsilon}}_{\alpha}(\mathbf{k}, t)$ ” to “ $\hat{\boldsymbol{\varepsilon}}_{\alpha}(\mathbf{k})$ ”; and in Equation (11.23) in the first line, omit the multiplication sign after ω :

$$\mathbf{c}(\mathbf{k}, t) = \sum_{\alpha=1}^2 \hat{\boldsymbol{\varepsilon}}_{\alpha}(\mathbf{k}) c_{\alpha}(\mathbf{k}, t) \quad (11.21)$$

.....

$$\dot{\mathbf{A}} = -\frac{\mathbf{i}}{(2\pi)^{\frac{3}{2}}} \sum_{\alpha} \int \omega [\hat{\boldsymbol{\varepsilon}}_{\alpha}(\mathbf{k}) \mathbf{c}_{\alpha}(\mathbf{k}, t) e^{i\mathbf{k}\cdot\mathbf{r}} - \hat{\boldsymbol{\varepsilon}}_{\alpha}(\mathbf{k})^* \mathbf{c}_{\alpha}(\mathbf{k}, t)^* e^{-i\mathbf{k}\cdot\mathbf{r}}] d^3\mathbf{k} \quad (11.23)$$

[4/06/2005]

- Page 360, just above Equation (11.25a): The t in $\dot{\mathbf{A}}(\mathbf{r}, t)$ should not be boldface:

The Fourier transform of the electric field $\mathbf{E}(\mathbf{r}, t) = -\dot{\mathbf{A}}(\mathbf{r}, t)$ is
 [Thanks to J. May, 6/14/2005]

- Page 360, Equation (11.26b): The closing bracket should be before the exponential:

$$= -\frac{i}{(2\pi)^{\frac{3}{2}}} \int \omega \hat{\mathbf{n}} \times [\mathbf{c}(\mathbf{k}, t)^* + \mathbf{c}(-\mathbf{k}, t)] e^{-i\mathbf{k}\cdot\mathbf{r}} d^3k \quad (11.26b)$$

[Thanks to D. Staszak, 4/24/2005]

- Page 361, Equation (11.30), in the first line, change the first “ c ” to boldface.

$$H = \frac{1}{4\pi} \int \omega^2 (\mathbf{c}(\mathbf{k}, t) \cdot \mathbf{c}^*(\mathbf{k}, t) + \mathbf{c}^*(\mathbf{k}, t) \cdot \mathbf{c}(\mathbf{k}, t)) d^3k \quad (11.30)$$

[Thanks to N. Kugland, 4/17/2006]

- Page 363, Equation 11.42: Replace $p_{\beta}(\mathbf{k}')$ with $p_{\beta}(\mathbf{k}', t)$

$$[H, x_{\beta}(\mathbf{k}', t)] = -ip_{\beta}(\mathbf{k}', t) = -i \frac{\partial x_{\beta}(\mathbf{k}', t)}{\partial t} \quad (11.42)$$

[4/09/2007]

- Page 364, just above Equation (11.52): There should be a space between “vector” and “ $\hat{\boldsymbol{\varepsilon}}(\mathbf{k})$ ”:

with momentum \mathbf{k} and polarization vector $\hat{\boldsymbol{\varepsilon}}(\mathbf{k})$.
 [Thanks to D. Staszak, 6/11/2005]

- Page 365, Equations (11.57) and (11.58): In both equations change $4pi$ to 4π .

$$\mathbf{E}(\mathbf{r}, t) = -\frac{\partial \mathbf{A}}{\partial t} = \frac{(4\pi)^{1/2}}{(2\pi)^{3/2}} i \int \frac{1}{\sqrt{2\omega}} \omega [\mathbf{a}(\mathbf{k}, t) - \mathbf{a}^{\dagger}(-\mathbf{k}, t)] e^{i\mathbf{k}\cdot\mathbf{r}} d^3k \quad (11.57)$$

and

$$\mathbf{B}(\mathbf{r}, t) = \nabla \times \mathbf{A} = -\frac{(4\pi)^{1/2}}{(2\pi)^{3/2}} i \int \frac{1}{\sqrt{2\omega}} \omega \hat{\mathbf{n}} \times [\mathbf{a}(-\mathbf{k}, t) + \mathbf{a}^{\dagger}(\mathbf{k}, t)] e^{-i\mathbf{k}\cdot\mathbf{r}} d^3k \quad (11.58)$$

[Thanks to M. Santonocito, 3/30/2004]

- Page 366, just above Equation (11.60): There should be a period after “vanishes”:

The last two terms are odd under this substitution, so the integral over them vanishes.
Thus

[Thanks to D. Staszak, 6/11/2005]

- Page 367, just above Equation (11.66): Change “(11.58)” to “(11.45)”:

From equations (11.57), (11.45), and (11.65).

[Thanks to D. Staszak, 6/11/2005]

- Page 370, Equation (11.81): \mathbf{A} and \mathbf{B} should be functions of \mathbf{r} only:

$$H'_{fi} = \left\langle \psi_f; \alpha, \mathbf{k} \left| \frac{e}{m} \mathbf{A}(\mathbf{r}) \cdot \mathbf{p} + \frac{e^2}{2m} \mathbf{A}(\mathbf{r})^2 + \frac{e}{2m} \boldsymbol{\sigma} \cdot \mathbf{B}(\mathbf{r}) \right| \psi_i \right\rangle \quad (11.79)$$

[4/09/2007]

- Page 371, Equation (11.86), first line: Replace $\delta(\mathbf{k}' - \mathbf{k})$ with $\delta_3(\mathbf{k}' - \mathbf{k})$:

$$H'_{fi} = \frac{e}{m} \frac{\sqrt{4\pi}}{(2\pi)^{3/2}} \sum_{\alpha'} \int \left\langle \psi_f \left| \hat{\boldsymbol{\epsilon}}_{\alpha'}^*(\mathbf{k}') \cdot \mathbf{p} e^{-i\mathbf{k}' \cdot \mathbf{r}} \right| \psi_i \right\rangle \frac{1}{\sqrt{2\omega'}} \delta_{\alpha', \alpha} \delta_3(\mathbf{k}' - \mathbf{k}) d^3 k' \quad (11.86)$$

[Thanks to J. May, 6/14/2005]

- Page 372, line above Equation (11.91): Insert “square of the” before ” matrix element:

The rate Γ is proportional to the square of the matrix element

[Thanks to Y. Guo, 5/03/2006]

- Page 374, Equation (11.106): Delete the second dagger superscript: Replace $a_{\alpha}^{\dagger}(\mathbf{k})^{\dagger}$ with $a_{\alpha}^{\dagger}(\mathbf{k})$:

$$\langle \gamma(\alpha, \mathbf{k}), 00 | \mathbf{p} \cdot \mathbf{A}(\mathbf{r}) | 1M \rangle \sim \langle \gamma(\alpha, \mathbf{k}), 00 | \hat{\boldsymbol{\epsilon}}_{\alpha}^*(\mathbf{k}) \cdot \mathbf{p} a_{\alpha}^{\dagger}(\mathbf{k}) e^{-i\mathbf{k} \cdot \mathbf{r}} | 1M \rangle \quad (11.106)$$

[Thanks to J. DeGrassie, 4/20/2005]

- Page 374, third line of last paragraph: Change “ \mathbf{p} and \mathbf{r} and act” to “ \mathbf{p} and \mathbf{r} act ”:

be ignored in this argument, since \mathbf{p} and \mathbf{r} act only on the space coordinates)

[Thanks to D. Matlock, 4/20/2005]

- Page 375, just above Equation (11.108): “if” should be “of”:

the effective part of the interaction Hamiltonian is

[Thanks to D. Matlock, 6/11/2005]

- Page 377, Equation (11.118), middle line: Replace “ B_{s_e} ” with “ \mathbf{s}_e ”:

$$\times \int \sum_{\alpha} \frac{\omega}{2} \left| \langle J=0 | \hat{\mathbf{n}} \times \hat{\boldsymbol{\epsilon}}_{\alpha}^*(\mathbf{k}) \cdot \mathbf{s}_e | J=1, M \rangle \right|^2 \delta(\Delta_{HFS} - \omega) d^3 k \quad (11.118)$$

[Thanks to L. Fredrikson, 4/20/2005]

- Page 382, Equation (11.147): ϵ_j should be ϵ_j^* , and $\hat{\epsilon}_{\alpha j}$ should be $\hat{\epsilon}_{\alpha j}^*$:

$$\epsilon_i \epsilon_j^* \rightarrow \frac{1}{2} \int \sum_{\alpha} \hat{\epsilon}_{\alpha i}(\mathbf{k}) \hat{\epsilon}_{\alpha j}^*(\mathbf{k}) d\Omega \bigg/ \int d\Omega = \frac{\delta_{ij}}{3} \quad (11.147)$$

[Thanks to Y. Guo, 5/04/2006]

- Page 385, In the paragraph between Equations (11.167) and (11.168) delete “. Therefore”:

Because $k_f^2/2m \gg |E_o|$, $k_f^2 \gg 1/a^2 \dots$
[2/18/2007]

- Page 387, Figure 11.1: In part (b) of the caption change “terms” to term”:

(b) a term with two photons in the intermediate state

[Thanks to Y. Guo, 5/04/2006]

- Page 388, Equations (11.182) and (11.183), the subscripts of $\hat{\epsilon}$ should be α , not γ :

$$\begin{aligned} & \langle \gamma_3 \gamma_4 \psi_n | \mathbf{p} \cdot \mathbf{A}(\mathbf{r}) | \gamma, \psi_o \rangle \\ &= \frac{\sqrt{4\pi}}{(2\pi)^{3/2}} \frac{1}{\sqrt{2\omega}} \langle \psi_n | \mathbf{p} \cdot \left(\hat{\epsilon}_{\alpha_4}^*(\mathbf{k}_4) e^{-i\mathbf{k}_4 \cdot \mathbf{r}} \delta_{\gamma_3 \gamma} + \hat{\epsilon}_{\alpha_3}^*(\mathbf{k}_3) e^{-i\mathbf{k}_3 \cdot \mathbf{r}} \delta_{\gamma_4 \gamma} \right) | \psi_o \rangle \end{aligned} \quad (11.182a)$$

$$\begin{aligned} & \langle \gamma', \psi_o | \mathbf{p} \cdot \mathbf{A}(\mathbf{r}) | \gamma_1 \gamma_2 \psi_n \rangle \\ &= \frac{\sqrt{4\pi}}{(2\pi)^{3/2}} \frac{1}{\sqrt{2\omega}} \langle \psi_o | \mathbf{p} \cdot \left(\hat{\epsilon}_{\alpha_2}(\mathbf{k}_2) e^{i\mathbf{k}_2 \cdot \mathbf{r}} \delta_{\gamma_1 \gamma'} + \hat{\epsilon}_{\alpha_1}(\mathbf{k}_1) e^{i\mathbf{k}_1 \cdot \mathbf{r}} \delta_{\gamma_2 \gamma'} \right) | \psi_n \rangle \end{aligned} \quad (11.182b)$$

.....

$$\begin{aligned} & \frac{e^2}{4m^2} \sum_n \sum_{\gamma_1 \gamma_2 \gamma_3 \gamma_4} \frac{4\pi}{(2\pi)^3} \frac{1}{2\omega} \delta_{\gamma_3 \gamma} \delta_{\gamma_1 \gamma_3} \delta_{\gamma_2 \gamma_4} \delta_{\gamma_1 \gamma'} \\ & \times \left[\langle \psi_n | \mathbf{p} \cdot \hat{\epsilon}_{\alpha_4}^*(\mathbf{k}_4) e^{-i\mathbf{k}_4 \cdot \mathbf{r}} | \psi_o \rangle \frac{1}{\omega + E_o - \omega_1 - \omega_2 - E_n} \langle \psi_o | \mathbf{p} \cdot \hat{\epsilon}_{\alpha_2}(\mathbf{k}_2) e^{i\mathbf{k}_2 \cdot \mathbf{r}} | \psi_n \rangle \right] \\ &= \frac{e^2}{4m^2} \sum_n \sum_{\gamma_2} \frac{4\pi}{(2\pi)^3} \frac{1}{2\omega} \delta_{\gamma' \gamma} \\ & \times \left[\langle \psi_n | \mathbf{p} \cdot \hat{\epsilon}_{\alpha_2}^*(\mathbf{k}_2) e^{-i\mathbf{k}_2 \cdot \mathbf{r}} | \psi_o \rangle \frac{1}{E_o - \omega - E_n} \langle \psi_o | \mathbf{p} \cdot \hat{\epsilon}_{\alpha_2}(\mathbf{k}_2) e^{i\mathbf{k}_2 \cdot \mathbf{r}} | \psi_n \rangle \right] \end{aligned} \quad (11.183)$$

[4/19/2006]

- Pages 390-391, In equations (11.187), (11.191), and (11.194), change $\tilde{\epsilon}_\alpha^*$ to $\tilde{\epsilon}_{\alpha'}^*$: [Thanks to Y. Guo, 5/03/2006]

- Page 392, Equation (11.200): Change \mathbf{q}' to \mathbf{q}'' :

$$\langle \mathbf{q}'' | e^{i\mathbf{k}\cdot\mathbf{r}} | \mathbf{q} \rangle = \frac{1}{(2\pi)^3} \int e^{-i\mathbf{q}''\cdot\mathbf{r}} e^{i\mathbf{k}\cdot\mathbf{r}} e^{i\mathbf{q}\cdot\mathbf{r}} d^3r = \delta_3(\mathbf{q} + \mathbf{k} - \mathbf{q}'') \quad (11.200)$$

[Thanks to Y. Guo, 5/23/2006]

- Page 396, Equation (11.216): In the third line, under the square-root sign, n should be n_z :

$$= \frac{L^2}{2\pi} \int_0^\infty \left[\frac{1}{2} k_{\parallel} + \sum_{n_z=1}^{\infty} \sqrt{k_{\parallel}^2 + \frac{n_z^2 \pi^2}{a^2}} \right] k_{\parallel} dk_{\parallel} \quad (11.216)$$

[4/26/2005]

- Page 396, Figure 11.2: The caption should end with a period.

embedded in a very large cube with volume L^3 .

[4/25/2006]

- Page 397, Equation (11.218): On the right replace \mathbf{n} with $|\mathbf{n}|$:

$$\omega_{\mathbf{n}} = \frac{\pi}{L} |\mathbf{n}| \quad (11.218)$$

[4/26/2005]

- Page 400, Equation (11.235), second line: Delete the extra parenthesis after F , and in Equation (11.237) delete “ $k_{\parallel} dk_{\parallel}$ ” just after the integral sign:

$$- \frac{a}{\pi} \int_0^\infty \sqrt{k_{\parallel}^2 + k_z^2} F \left(\sqrt{k_{\parallel}^2 + k_z^2} \right) dk_z \left] k_{\parallel} dk_{\parallel} \quad (11.235)$$

.....

$$f(n) = \int_0^\infty \sqrt{k_{\parallel}^2 + \frac{n^2 \pi^2}{a^2}} F \left(\sqrt{k_{\parallel}^2 + \frac{n^2 \pi^2}{a^2}} \right) k_{\parallel} dk_{\parallel} \quad (11.237)$$

[4/26/2005]

- Page 400, Equation (11.238): The first pair of parentheses in the middle line should be the same size as the second:

$$= \frac{B_2}{2!} \left(f'(0) - f'(N) \right) + \frac{B_4}{4!} \left(f^{(3)}(0) - f^{(3)}(N) \right) \quad (11.238)$$

[Thanks to Y. Guo, 5/23/2006]

- Page 403, Problem 11.5: Delete the sentence “What is the width of these components of the Lyman- β line?”

Compute the rate for the spontaneous decay of a $3P$ state to the $1S$ state. (Here you can ignore spin—these are electric transitions.)

[Thanks to K. Lane, 5/13/2004]

Chapter XII

- Page 409, Equation (12.14c): Change x to z :

$$z' = z \quad (12.14c)$$

[Thanks to K. Lane, 5/13/2004]

- Page 409, Equation (12.18), in the denominator, $v_1 v_1$ should be $v_1 v_2$:

$$\tanh(\omega_1 + \omega_2) = \frac{v_1 + v_2}{1 + v_1 v_2} \quad (12.18)$$

[Thanks to F. O'shea and J. Wright, 5/12/2006]

- Page 410, Equations (12.20): The exponents should be boldface:

$$\bar{R} = e^{-i\theta \hat{\mathbf{n}} \cdot \bar{\mathbf{J}}} \quad (12.20a)$$

$$\bar{B} = e^{-i\omega \hat{\mathbf{n}} \cdot \bar{\mathbf{K}}} \quad (12.20b)$$

[1/04/2004]

- Page 411, Equation (12.33): In the third and fourth lines, change m_j and m_k to m_x and m_y , respectively.

$$\begin{aligned} X_z |x, m_x, y, m_y\rangle &= m_x |x, m_x, y, m_y\rangle \\ Y_z |x, m_x, y, m_y\rangle &= m_y |x, m_x, y, m_y\rangle \end{aligned} \quad (12.33)$$

[Thanks to E. Hemsing, 5/10/2005]

- Page 422, just below Equation (12.111): ϕ_1 should be ϕ_2 :

Solve equation (12.110b) for ϕ_2 and insert the result into (12.110a):
[5/11/2005]

- Page 432, Equation (12.175): ψ should be ϕ , six times:

$$\mathcal{R} \begin{pmatrix} \phi_1(\mathbf{r}) \\ \phi_2(\mathbf{r}) \end{pmatrix} = \gamma^o \begin{pmatrix} \phi_1(-\mathbf{r}) \\ \phi_2(-\mathbf{r}) \end{pmatrix} = \begin{pmatrix} \phi_1(-\mathbf{r}) \\ -\phi_2(-\mathbf{r}) \end{pmatrix} \quad (12.175)$$

[Thanks to T. Tao, 5/20/2005]

- Page 436, Problem 12.2, Part (b): In the last line, “ \bar{J} and \bar{K} ” should read “ \bar{J}_i and \bar{K}_i ”:

Show that no change of basis can transform the six four-dimensional matrices $D(\bar{J}_i)$ and $D(\bar{K}_i)$ in the Dirac representation into the six four-dimensional matrices \bar{J}_i and \bar{K}_i .

[Thanks to J. May, 6/14/2005]

- Page 436, Problem 12.4, Part (a): Replace “eigenvalues” by “energy levels” and insert “in” before “powers”:

Expand the energy levels (12.71) of the Klein-Gordon equation in a Coulomb potential in powers of α

[Thanks to A. Tableman, 5/17/2006]

- Page 437, in the sentence before the last reference: Replace “extacting” with “extracting”:

The correct method for extracting the nonrelativistic limit of the Dirac equation is due to

[Thanks to D. Staszak, 5/24/2005]

Chapter XIII

- Page 438, second Paragraph, third line: Change “containg” to “containing”:

That is a way to describe any kind of physical system containing many identical particles,

[Thanks to E. Hemsing, 5/29/2005]

- Page 439, Equations (13.9) through (13.11): Change “ pi ” to the Greek letter π four times:

$$\Psi(\mathbf{r}) = \frac{1}{(2\pi)^{3/2}} \int e^{i\mathbf{p}\cdot\mathbf{r}} a(\mathbf{p}) d^3p \quad (13.9)$$

Then

$$\Psi^\dagger(\mathbf{r})|\rangle = \frac{1}{(2\pi)^{3/2}} \int e^{-i\mathbf{p}\cdot\mathbf{r}} a^\dagger(\mathbf{p})|\rangle d^3p = \frac{1}{(2\pi)^{3/2}} \int e^{-i\mathbf{p}\cdot\mathbf{r}} |\mathbf{p}\rangle d^3p \quad (13.10)$$

This is a one-particle state whose wave function is

$$\psi(\mathbf{r}') = \langle \mathbf{r}' | \Psi^\dagger(\mathbf{r}) | \rangle = \frac{1}{(2\pi)^{3/2}} \int e^{-i\mathbf{p}\cdot\mathbf{r}} \langle \mathbf{r}' | \mathbf{p} \rangle d^3p = \delta_3(\mathbf{r} - \mathbf{r}') \quad (13.11)$$

[Thanks to M. Gutperle, 6/09/2004]

- Page 440, Equation (13.15): Change “ pi ” to the Greek letter π :

$$\phi(\mathbf{p}) = \frac{1}{(2\pi)^{3/2}} \int \psi(\mathbf{r}) e^{-i\mathbf{p}\cdot\mathbf{r}} d^3r \quad (13.15)$$

[Thanks to J. Champer, 6/02/2005]

- Page 440, Equation (13.20): In the next-to-last expression, change \mathbf{r}' to \mathbf{r} :

$$[a_i, a_j^\dagger] = \iint \psi_i^*(\mathbf{r}') \psi_j(\mathbf{r}) [\Psi(\mathbf{r}'), \Psi^\dagger(\mathbf{r})] d^3r' d^3r = \int \psi_i^*(\mathbf{r}) \psi_j(\mathbf{r}) d^3r = \delta_{ij} \quad (13.20)$$

[5/18/2005]

- Page 441, Equation (13.25): In the first row, change $a^\dagger(\mathbf{p})$ to $a^\dagger(\mathbf{p}')$

$$H = \frac{1}{2m} \int \mathbf{p}' \cdot \mathbf{p} a^\dagger(\mathbf{p}') a(\mathbf{p}) \delta_3(\mathbf{p}' - \mathbf{p}) d^3p d^3p' \quad (13.25)$$

[5/17/2006]

- Page 441, Equation (13.28): In the last term, replace v with v_2 :

$$H = \frac{1}{2m} \int \nabla \Psi^\dagger(\mathbf{r}) \cdot \nabla \Psi(\mathbf{r}) d^3r + \frac{1}{2} \int v_2(\mathbf{r}_1, \mathbf{r}_2) \Psi^\dagger(\mathbf{r}_1) \Psi^\dagger(\mathbf{r}_2) \Psi(\mathbf{r}_1) \Psi(\mathbf{r}_2) d^3r_1 d^3r_2 \quad (13.28)$$

[Thanks to T. Tao, 5/26/2005]

- Page 441, (Equation 13.30) and Page 442, Equation (13.31): In the denominators, change “ π ” to the Greek letter “ π ”:

$$\Psi(\mathbf{r}, t) = \frac{1}{(2\pi)^{3/2}} \int e^{i\mathbf{p}\cdot\mathbf{r}} a(\mathbf{p}, t) d^3p = \frac{1}{(2\pi)^{3/2}} \int e^{i\mathbf{p}\cdot\mathbf{r}} a(\mathbf{p}) e^{-i\omega t} d^3p \quad (13.30)$$

The field satisfies an equation of motion:

$$i \frac{\partial \Psi(\mathbf{r}, t)}{\partial t} = \frac{1}{(2\pi)^{3/2}} \int \frac{\mathbf{p}^2}{2m} e^{i\mathbf{p}\cdot\mathbf{r}} a(\mathbf{p}) e^{-i\omega t} d^3p = -\frac{\nabla^2}{2m} \Psi(\mathbf{r}, t) \quad (13.31)$$

[5/18/2005]

- Page 442, Equation (13.37): Change “ π ” to the Greek letter π :

$$\Psi_s(\mathbf{r}) = \frac{1}{(2\pi)^{3/2}} \int V_s(\mathbf{p}) e^{i\mathbf{p}\cdot\mathbf{r}} a_s(\mathbf{p}) d^3p \quad (13.37)$$

[Thanks to J. Champer, 6/02/2005]

- Page 452, just above the subheading “**Neutron Stars**”: Change the period after g to a comma:

gives the critical mass, called the **Chandrasekhar limit** [1,2], as about 2.4×10^{33} g, or 1.4 times the mass of the sun.

[Thanks to J. May, 6/14/2005]

- Page 455, Equation (13.121): Change \mathbf{r} to \mathbf{k} (four times)

$$[a(\mathbf{k}'), a^\dagger(\mathbf{k})] = \delta_3(\mathbf{k}' - \mathbf{k}) \quad (13.121)$$

[6/02/2005]

- Page 457, Equation (13.131): In the middle expression, in the denominator, ϕ should be $\dot{\phi}$:

$$\Pi(x) = \frac{\partial \mathcal{L}}{\partial \dot{\phi}(x)} = \dot{\phi}^\dagger \quad (13.131)$$

[Thanks to J. Wright, 6/06/2006]

- Page 458, second full paragraph: Change the second d^\dagger to b^\dagger :

The particles created by $d^\dagger(\mathbf{k})$ are the **antiparticles** of the ones created by $b^\dagger(\mathbf{k})$.

[Thanks to E. Hemsing and D. Matlock, 6/01/2005]

- Page 459, Equation (3.154). Change the subscript i to s :

$$\psi(x) = w_s(\mathbf{k}, t) e^{i\mathbf{k}\cdot\mathbf{r}} = w_s(\mathbf{k}) e^{i(\mathbf{k}\cdot\mathbf{r} - Et)} \quad (13.154)$$

[5/31/2006]

- Page 460, Equatons (13.155) and (13.161): in the first factor on the left, pi should be Greek letter π :

$$\psi(x) = \frac{1}{(2\pi)^{3/2}} \int \frac{1}{\sqrt{2\omega}} \left[\sum_{s=1}^2 b_s(\mathbf{k}) w_s(\mathbf{k}) e^{-i\omega t} + \sum_{s=3}^4 d_s^\dagger(\mathbf{k}) w_s(\mathbf{k}) e^{i\omega t} \right] e^{i\mathbf{k}\cdot\mathbf{r}} d^3k \quad (3.155)$$

$$\psi(x) = \frac{1}{(2\pi)^{3/2}} \sum_{s=1}^2 \int \frac{1}{\sqrt{2\omega}} [b_s(\mathbf{k}) u_s(\mathbf{k}) e^{-ik\cdot x} + d_s^\dagger(\mathbf{k}) v_s(\mathbf{k}) e^{ik\cdot x}] d^3k \quad (13.161)$$

[11/15/2004]

- Page 460, Equation (3.155): Change d^\dagger to b^\dagger . In Equations (13.158) and (13.159), change i to s . And in Equation (3.159) add “and $d_s^\dagger(\mathbf{k}) = b_{s+2}^\dagger(-\mathbf{k})$ ”:

$$\psi(x) = \frac{1}{(2\pi)^{3/2}} \int \frac{1}{\sqrt{2\omega}} \left[\sum_{s=1}^2 b_s(\mathbf{k}) w_s(\mathbf{k}) e^{-i\omega t} + \sum_{s=3}^4 b_s^\dagger(\mathbf{k}) w_s(\mathbf{k}) e^{i\omega t} \right] e^{i\mathbf{k}\cdot\mathbf{r}} d^3k \quad (3.155)$$

.....

$$u_s(\mathbf{k}) = w_s(\mathbf{k}) \quad (13.158)$$

but for the negative energy solutions

$$v_s(\mathbf{k}) = w_{s+2}(-\mathbf{k}) \quad \text{and} \quad d_s^\dagger(\mathbf{k}) = b_{s+2}^\dagger(-\mathbf{k}) \quad (13.159)$$

[5/31/2006]

- Page 461, in the first line of Equation (13.167): Add “ d^3x ” on the right:

$$H = \int \mathcal{H}(x) d^3x = \int \psi^\dagger(x) (-i\boldsymbol{\alpha} \cdot \nabla + m\gamma^0) \psi(x) d^3x \quad (13.167)$$

.....

[Thanks to L. Fredrickson, 6/06/2005]

- Page 463, just above Equation (13.175): Delete the word “of”:

Explicitly, break the field into two parts:
[Thanks to D. Staszak, 6/08/2005]

- Page 463, Equation (13.178): Change “ pi ” to the Greek letter π :

$$f(\mathbf{k}) = \frac{1}{(2\pi)^{3/2}} \frac{1}{\sqrt{2\omega}} e^{-i\mathbf{k}\cdot\mathbf{r}} \quad (13.178)$$

[6/02/2005]

- Page 464, Equation (13.190): replace \mathbf{p}_3 with \mathbf{p}_1 :

$$a(\mathbf{k}_1)a(\mathbf{k}_2)|\mathbf{p}_1, \mathbf{p}_2\rangle = [\delta_3(\mathbf{k}_1 - \mathbf{p}_1)\delta_3(\mathbf{k}_2 - \mathbf{p}_2) + \delta_3(\mathbf{k}_1 - \mathbf{p}_2)\delta_3(\mathbf{k}_2 - \mathbf{p}_1)]| \rangle \quad (13.190)$$

[Thanks to J. Ma and E. Nelson, 6/08/2006]

- Page 466, in the line just below the first equation: Replace “ a and b are have” with “ a and b have”:

where a are b have the algebra of a single boson and fermion mode, respectively:
[Thanks to D. Staszak, 11/20/2004]

- Page 468, Equation (13.199): The second “ ψ ” should be upper case “ Ψ ”. Also, for stylistic consistency none of the equations in the Problems section should be numbered:

$$C_{rs}(|\mathbf{r} - \mathbf{r}'\rangle) = \langle N_o | \Psi_r^\dagger(\mathbf{r})\Psi_s^\dagger(\mathbf{r}')\Psi_s(\mathbf{r}')\Psi_r(\mathbf{r}) | N_o \rangle$$

[Thanks to D. Staszak, 6/01/2005]

Appendix

- Page 483, Equation (A.103): the ϕ in the denominator should be squared. and in Equation (A.104), on the left, delete the primes in $Y_l^{m'}$:

$$-\left(\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\sin\theta\frac{\partial}{\partial\theta} + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}\right)Y_l^m(\theta, \phi) = l(l+1)Y_l^m(\theta, \phi) \quad (A.103)$$

They are conventionally normalized on the unit sphere so that

$$\int Y_l^m(\theta, \phi)^* Y_l^m(\theta, \phi) d\Omega = 1 \quad (A.104)$$

[Thanks to J. Wright, 2/12/2006]

- Page 484, Equation (A.109): In the first term on the right-hand side, replace $(+1)$ by $(l+1)$:

$$\frac{d^2}{d\rho^2} [\rho h_l^{(1)}(\rho)] = \left[\frac{l(l+1)}{\rho^2} - 1 \right] \rho h_l^{(1)}(\rho) + 2i(l+1)\rho^l \int_1^{1+i\infty} z e^{i\rho z} (1-z^2)^l dz \quad (A.109)$$

[Thanks to C. Seager, 11/16/2005]

- Page 486, In Figure A.2, replace ‘ $f(z)$ ’ by ‘ $f(\rho)$ ’:

$$f(z) = \frac{\rho^l}{2^{l+1}l!} \int e^{i\rho z} (1 - z^2)^l dz$$

[6/15/2009]

- Page 491, In the line below equation (A.146), replace “or” by “of”:

In this way we have determined the asymptotic behavior of these Bessel functions
[Thanks to N. Kugland, 5/31/2006]

- Page 493, (Equation A.158). Change “ h_1 ” to “ h_i ”:

$$\nabla_{q_i} = \frac{1}{h_i} \frac{\partial}{\partial q_i} \quad (\text{A.158})$$

[Thanks to B. Fahimian, 10/25/2005]

- Page 495, Equations (A.174) and (A.175): On the left, the symbol V should be in boldface: In cylindrical coordinates,

$$(\nabla \times \mathbf{V})_\rho = \frac{1}{\rho} \frac{\partial V_z}{\partial \phi} - \frac{\partial V_\phi}{\partial z} \quad (\text{A.174a})$$

$$(\nabla \times \mathbf{V})_\phi = \frac{\partial V_\rho}{\partial z} - \frac{\partial V_z}{\partial \rho} \quad (\text{A.174b})$$

$$(\nabla \times \mathbf{V})_z = \frac{1}{\rho} \frac{\partial(\rho V_\phi)}{\partial \rho} - \frac{1}{\rho} \frac{\partial V_\rho}{\partial \phi} \quad (\text{A.174c})$$

and in spherical coordinates,

$$(\nabla \times \mathbf{V})_r = \frac{1}{r \sin \theta} \left[\frac{\partial(\sin \theta V_\phi)}{\partial \theta} - \frac{\partial V_\theta}{\partial \phi} \right] \quad (\text{A.175a})$$

$$(\nabla \times \mathbf{V})_\phi = \frac{1}{r} \frac{\partial}{\partial r} (r V_\theta) - \frac{1}{r} \frac{\partial V_r}{\partial \theta} \quad (\text{A.175b})$$

$$(\nabla \times \mathbf{V})_\theta = \frac{1}{r \sin \theta} \frac{\partial V_r}{\partial \phi} - \frac{1}{r} \frac{\partial}{\partial r} (r V_\phi) \quad (\text{A.175c})$$

[6/06/2007]

- Page 499, first line. $\mathbf{R}/2$ should be $\pm \mathbf{R}/2$:

The surfaces of constant u are ellipsoids with foci at $\pm \mathbf{R}/2$
[Thanks to J. Landy, 2/13/2007]

- Page 500, near the end of the first paragraph, change “an more elegant” to “a more elegant”:

is an introduction to a more elegant treatment
[Thanks to N. Kugland, 5/01/2006]

- Page 500, first line of section B.1.1: Y_m^l should be Y_l^m :

There are some relations between the spherical harmonics $Y_l^m(\theta, \phi)$ and the...
[Thanks to E. Perlmutter, 11/16/2006]

- Page 507, Equation (B.60): $d_{-q,q}^{(j)}$ should be $d_{-q,q}^{(j)}(\pi)$:

$$d_{-q,q}^{(j)}(\pi) = (-1)^{j-q} \tag{B.60}$$

[12/06/2009]

- Page 516, change Robert L. Liboff to Richard L. Liboff:

Richard L. Liboff, *Introductory Quantum Mechanics* (Addison-Wesley, 2003)
[Thanks to D. Dicus, 9/19/2008]