Errata for Quantum Mechanics

by Ernest Abers

All mistakes found before September 30, 2008 by page (1st and 2nd printings)

Chapter I

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

  Examples of vector observables are **r**, **p**, and **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 2, just above Equation (1.5): Change "third" to "second":

  With these definitions Newton's second law
  [Thanks to J. Schilling, 1/11/2005]

- Page 4, Equation (1.16), in the second equation, first term on the right, r_i should have only one dot.

$$\frac{\partial L}{\partial \dot{r}_i} = m\dot{r}_i + \frac{q}{c}A_i \tag{1.16}$$

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

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

  thermodynamics. Think of L as a function with p instead of $\dot{q}$ as one of the
  [Thanks to J. May, 10/11/2004]

- Page 5, Equation (1.24): Delete the factor m that appears before the first summation sign:

$$H = \sum_k p_k \dot{q}_k - L = m \sum_k \left(\frac{p_k}{m}\right)^2 - L = 2T - T + V = T + V \tag{1.24}$$

  [Thanks to D. Matlock, 10/06/2004]

- 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:

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

  [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:

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

  [10/06/2004]

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

  [6] I reserve the notation $\bar{R}(\hat{\boldsymbol{n}}, \theta)$ for these real 3×3 matrices, to distinguish them from the abstract operation $R(\hat{\boldsymbol{n}}, \theta)$ 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 12, Equation (1.58): Insert i before the first ϵ.

$$(\bar{J}_i)_{jk} = \bar{J}(\hat{\boldsymbol{n}}_i)_{jk} = i\epsilon_{ikj} = -i\epsilon_{ijk} \tag{1.58}$$

  [10/07/2004]

- Page 12: Delete the first sentence immediately below equation (1.64):

$$\delta L = \frac{d}{dt}\delta\Omega(q, \dot{q}, t) \tag{1.64}$$

  This rule must hold as a consequence of the functional form of L, for any $q_k(t)$ whether or not they satisfy the equations of motion. Let
  [Thanks to M. Eides, 8/26/2005]

- Page 14, Equation (1.78): The last expression needs an ϵ in front:

$$G = \sum_{m,i} p_{m,i}\delta r_{m,i} = \epsilon \sum_{ijk} \epsilon_{ijk} p_{m,i} n_j r_{m,k} = \epsilon \sum_m (\mathbf{r}_m \times \mathbf{p}_m) \cdot \hat{\boldsymbol{n}} = \epsilon \mathbf{L} \cdot \hat{\boldsymbol{n}} \tag{1.78}$$

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

- 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 "$\epsilon <= 1$" 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, Equation (2.2): In the leftmost expression, change $\hbar$ to h:

$$\frac{h}{p} = \lambda = \frac{2\pi\hbar}{\sqrt{2mE}} \approx 1.2\,\text{Å} \tag{2.2}$$

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

- 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, Equation (2.6a): Change the last α to β:

$$\Big[\alpha + \beta\Big]|\psi\rangle = \alpha|\psi\rangle + \beta|\psi\rangle \tag{2.6a}$$

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

- Page 25, Equation (2.6b): β should be α:

$$\alpha\Big[|\psi_1\rangle + |\psi_2\rangle\Big] = \alpha|\psi_1\rangle + \alpha|\psi_2\rangle \tag{2.6b}$$

  [Thanks to D. Staszak, 11/09/2004]

- 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 28, Equation (2.35): Change the subscript i to n:

$$\sum_n |\psi_n\rangle\langle\psi_n|\ \psi\rangle = |\psi\rangle \tag{2.35}$$

  [Thanks to D. Gangadharan, 11/01/2004]

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

$$|\alpha\rangle = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \ldots \\ \alpha_n \end{pmatrix} \qquad |\beta\rangle = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \ldots \\ \beta_n \end{pmatrix} \tag{2.52}$$

  [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 $\psi_\mathbf{r}$:

$$\int_{x_o}^{x_o+\Delta x} |\langle\psi|\ \psi_x\rangle|^2\, dx \tag{2.85}$$

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

  [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:

$$[q_j, p_i] = i\delta_{ij} \tag{2.125a}$$

  [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 "$|\psi\rangle$":

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

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

- Page 42, Equation (2.127): the sign is wrong:

$$i\hbar \frac{d}{dt}\langle A\rangle = \big\langle [A, H(t)] \big\rangle \tag{2.127}$$

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

- 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.

$$\boxed{\hbar = 1.054572\ldots \times 10^{-27}\,\text{erg-sec}} \tag{2.130}$$

  [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. equation (2.177): In the last matrix element, the operator x'' should be just x:

  $$\langle\psi_{x'+a}|\, x\, |\psi_{x''+a}\rangle = (x'' + a)\,\langle\psi_{x'}|\, \psi_{x''}\rangle = \langle\psi_{x'}|\, x + aI\, |\psi_{x''}\rangle \tag{2.177}$$

  [10/20/2004]

- 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

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

  and similarly

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

  so that

  $$\langle\psi|\, x^2\, |\psi\rangle\langle\Psi|\, p^2\, |\psi\rangle = \frac{1}{4}\hbar^2 \tag{2.199}$$

  [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 "≥" 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 54, Equation (2.216): In the last term, in the denominator, replace k by k^2:

$$\omega t - kx = \omega_o t - k_o x + (k - k_o)\left[v_g(k_o)t - x\right] + \frac{1}{2}(k - k_o)^2 \frac{d^2\omega(k_o)}{dk^2} t + \cdots \quad (2.216)$$

  [10/20/2004]

- Page 54, equation (2.218): In the last expression, delete $\sqrt{2\pi}$ in the denominator:

$$= e^{-i(\omega_o - k_o v_g)t}\Psi(x - v_g t)$$

  [Thanks to T. Tao, 10/20/2004]

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

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

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

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

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

  [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:

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

  [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.

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

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

- Page 80, Equation (3.114): In the middle two expressions (but not in the other two) the subscript $l-1$ should be just l:

$$\begin{aligned} H|E_{l,l-1}, l, l-1\rangle &= \frac{1}{\sqrt{2l}} HL_-|E_{l,l}, l, l\rangle \\ &= \frac{1}{\sqrt{2l}} L_-H|E_{l,l}, l, l\rangle = E_l|E_{l,l-1}, l, l-1\rangle \end{aligned} \tag{3.114}$$

  [Thanks to J. May, 11/09/2004]

- Page 81, Equation (3.119): Insert an equals sign before $F(r,\theta)$:

$$\psi(r,\theta,\phi) = F(r,\theta)e^{im\phi} \tag{3.119}$$

  [11/01/2004]

- Page 81, Equations (3.120) and (3.123): In the denominator just before the closing parenthesis, change ϕ to ϕ^2:

$$\mathbf{L}^2\psi_{Elm}(\mathbf{r}) = -\left(\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\sin\theta\frac{\partial}{\partial\theta} + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}\right)\psi_{Elm}(r,\theta,\phi) \tag{3.120}$$

$$\mathbf{L}^2 Y_l^m(\theta,\phi) = -\left(\frac{1}{\sin\theta}\frac{\partial}{\partial\theta}\sin\theta\frac{\partial}{\partial\theta} + \frac{1}{\sin^2\theta}\frac{\partial^2}{\partial\phi^2}\right)Y_l^m(\theta,\phi) \tag{3.123}$$

  [Thanks to D. Matlock, 11/01/2004]

- Page 81, Equation (3.l22): Replace r in the exponent by ϕ:

$$\psi_{Elm}(\mathbf{r}) = F(r,\theta)e^{im\phi} = R_{Elm}(r)Y_l^m(\theta,\phi) \tag{3.122}$$

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

- Page 82, Equation (3.128): "$R_{El}(r)$" should be "$R_{El}(r)^2$":

$$\int_0^\infty R_{El}(r)^2 r^2 dr = 1 \tag{3.128}$$

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

- 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. Stazsak, 12/15/2004]

- Page 84, Equation (3.137): The last term should be Ze^2/r:

$$H = \frac{\mathbf{p}^2}{2m} - \frac{Ze^2}{r} \tag{3.137}$$

  [Thanks to K. Lane, 10/23/2003]

- 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. Stazsak, 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":

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

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

- Page 90, Equation (3.172): Change m to M in the equation and in the next line:

$$n - l - 1 = M \qquad (3.172)$$

  for some nonnegative integer M.

  [Thanks to K. Lane, 10/23/2003]

- Page 94, Problem 3.8, part (a), first line: Delete "Hermitean".

  Let A be any well-defined operator, and
  [Thanks to A. Kao, 11/08/2006]

- 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]

- Page 101, Problem 3.22, part (e): Change "see Problem 2.1" to "see Section 2.6."
  [11/07/2004]

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 $D(\hat{\boldsymbol{n}},\psi)$ about $\hat{\boldsymbol{n}}$ 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 expresion, change outer parentheses to brackets:

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

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

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

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

  [11/15/2004]

- Page 114, Equation (4.60): On the right, change the summation index from m' to m'':

$$\begin{aligned} R(\hat{\boldsymbol{n}}_1,\theta_1)R(\hat{\boldsymbol{n}}_2,\theta_2)|\mathbf{r},m\rangle &= \sum_{m'} R(\hat{\boldsymbol{n}}_1,\theta_1)|\mathbf{r}',m'\rangle D_{m'm}(\hat{\boldsymbol{n}}_1,\theta_1) \\ &= \sum_{m''} |\mathbf{r}'',m''\rangle \left[D(\hat{\boldsymbol{n}}_2,\theta_2)D(\hat{\boldsymbol{n}}_1,\theta_1)\right]_{m''m} \end{aligned} \tag{4.60}$$

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

- 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.

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

  [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 122, just above Equation (4.105): Insert "solutions" between "the" and "to":

  The eigenstates are linear combinations of $|1,-1/2\rangle$ and $|0,1/2\rangle$. The eigenvalues are the solutions to the characteristic equation:
  [Thanks to K. Lane, 1/12/2004]

- 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.

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

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

  [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:

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

  ....

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

  [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]

- Page 129, above Equation (4.146): Change "left-hand side" to "right-hand side":

  On the right-hand side, use
  [Thanks to J. May, 4/11/2005]

- Page 131, Problem 4.2, part (b): Change the superscript j to 1:

$$\sum_{mn} U_{am} D^{(1)}(\bar{J}_i)_{mn} U^\dagger_{nb} = \left(\bar{J}_i\right)_{ab}$$

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

- Page 132, Problem 4.4, part (c): The last equation on the page should be changed to

$$\psi(\mathbf{r}) = R^{\pm}_{El}(r)\mathcal{Y}_l^{m\pm}(\theta,\phi)$$

[Thanks to K. Lane, 11/03/2003]

- Page 133, Problem 4.6, second equation: Delete the summation sign on the far left.

$$\mathbf{J}_i \cdot \mathbf{J}_i|\psi_{m_1m_2m_3}\rangle = j_i(j_i+1)|\psi_{m_1m_2m_3}\rangle$$

[Thanks to A. Forrester, 12/08/2005]

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	$\mathrm{n} \to \mathrm{p} + \mathrm{e}^- + \bar{\nu}_e$
....	....	....	....	....
π^-	139.570	0	2.6×10^{-8}	$\pi^- \to \mu^- + \bar{\nu}_\mu$

[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 "eV^2":

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

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

- Page 140, on the line just below Equation (5.6): Change $g(a)$ to $g(\epsilon)$:

  For a one-parameter subgroup of continuous symmetries $g(\epsilon) = \exp(-i\epsilon G)$,
  [Thanks to K. Lane, 1/12/2004]

- 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 142, footnote: $Y^l_m(\hat{\boldsymbol{n}})$ should read $Y^m_1(\hat{\boldsymbol{n}})$:

  This is because the spherical harmonics $Y^m_1(\hat{\boldsymbol{n}})$ are the spherical components of the unit vector $\hat{\boldsymbol{n}}$.
  [Thanks to Y. Guo, 1/23/2006]

- 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^q_κ with $\langle\alpha', j', m'|\, T^q_\kappa \,|\alpha, j, m\rangle$:

  Therefore, $\langle\alpha', j', m'|\, T^q_\kappa \,|\alpha, j, m\rangle = 0$ 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 $(\bar{R})$:

$$R(\bar{R})|\alpha, j_1, m_1, j_2, m_2\rangle = \sum_{m_1', m_2'} |\alpha, j_1, m_1', j_2, m_2'\rangle D^{(j_1)}_{m_1' m_1}(\bar{R}) D^{(j_2)}_{m_2' m_2}(\bar{R}) \tag{5.64}$$

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

- Page 157, Equation (5.109). Replace the last $-m$ by m:

$$\mathcal{T}^2|\alpha, j, m\rangle = (-1)^{j-m} e^{-i\delta} \mathcal{T}|\alpha, j, -m\rangle = (-1)^{2j}|\alpha, j, m\rangle \tag{5.109}$$

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

- Page 158, fifth paragraph, sixth line, delete one occurence 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:

$$|\psi\rangle = |E_1, l_1, j_1, m_1, E_1, l_1, j_1, m_1\rangle \tag{5.112}$$

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

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

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

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

- Page 163, Equation (5.131): Insert $\sum_j$ just after the equals sign:

$$\bar{N}_i \to \sum_j \bar{N}_j \left[D^{(\frac{1}{2})}(\hat{\boldsymbol{n}}, \theta)^\dagger\right]_{ji} = \sum_j \left[D^{(\frac{1}{2})}(\hat{\boldsymbol{n}}, \theta)^*\right]_{ij} \bar{N}_j \tag{5.131}$$

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

Chapter VI

- Page 171, Section 6.1.1, Second paragraph, fourth line: Replcace "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): "$\mathbf{A'r}$)" should read "$\mathbf{A}'(\mathbf{r})$":

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

[1/09/2006]

- Page 175, Equation (6.29): L_z should be H_2:

$$H_1|N,k\rangle = (N+1)\omega|N,k\rangle \qquad \text{and} \qquad H_2|N,k\rangle = \frac{eB}{|eB|}\omega k|N,k\rangle \tag{6.29}$$

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

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

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

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

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

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

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

- Page 179, just above Equation (6.53): "a" should be "λ_a":

The eigenvalue λ_a cannot be negative:
[1/09/2005]

- Page 180, in the first sentence of the second paragraph: Replace "each way of distributing the particles is equally likely" with "when the n_i correspond to the most probable distribution":

The collection of particles is in thermal equilibrium when the n_i correspond to the most probable distribution, subject
[1/09/2005]

- Page 181, just above Equation (6.68): Replace "traceless Hermitean matrix" with "Hermitean matrix with unit trace."

Here the density matrix is a 2×2 Hermitean matrix with unit trace.
[Thanks to T. Tao, 2/15/2005]

- Page 183, Equation (6.81): Change "$\mathbf{B}$" on the left to "$\mathbf{B}_1(t)$" and "$\mathbf{B}_1$" on the right to "B_1". Just above Equation (6.82) add "(with $\omega_1 = g\mu_B B_1$)":

$$\mathbf{B}_1(t) = B_1(\hat{\boldsymbol{n}}_x\cos\omega t + \hat{\boldsymbol{n}}_y\sin\omega t) \tag{6.81}$$

...The Hamiltonian matrix has the form (6.71), with $H_o = 0$ and (with $\omega_1 = g\mu_B B_1$)
[1/20/2005]

- 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

$$\frac{d}{dt}\left[\mathbf{P}\cdot\hat{\boldsymbol{n}}'_i(t)\right] = \sum_{jk}\epsilon_{ijk}H'_jP'_k - \sum_{k}\epsilon_{ijk}\omega_jP'_k \tag{6.87}$$

  [1/15/2005]

- Page 183, in the paragraph below Equation (6.84): Replace "$\mathbf{H}'$" with "$\mathbf{H}$" twice. The last line of that paragraph should read "$\mathbf{P}_o = -\hat{\boldsymbol{n}}'_z$ also". In equation (6.88) delete both primes on the right-hand side, and add a prime after the closing bracket, above the subscript "i":

  In the rotating frame $\mathbf{H}$ has constant components: $\mathbf{H} = \omega_o\hat{\boldsymbol{n}}'_z + \omega_1\hat{\boldsymbol{n}}'_x$...

  $\mathbf{P}_o = -\hat{\boldsymbol{n}}'_z$ also.

$$\frac{d}{dt}P'_i = \left[\,(H-\boldsymbol{\omega})\times\mathbf{P}\right]'_i \tag{6.88}$$

  [1/20/2005]

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

$$\frac{d}{dt}\left[\mathbf{P}\cdot\hat{\boldsymbol{n}}'_i(t)\right] = \sum_{jk}\epsilon_{ijk}H'_jP'_k - \sum_{jk}\epsilon_{ijk}\omega_jP'_k \tag{6.87}$$

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

- Page 184, at the very top: Add "where the prime attached to the bracket means that the vector is to be resolved along the i-th *rotating* axis.":

  where the prime attached to the bracket means that the vector is to be resolved along the i-th *rotating* axis. Since $\mathbf{H}' - \boldsymbol{\omega}$ is a constant vector...
  [1/20/2005]

- Page 186, fourth line: Replace "10^{-15}" with "10^{15}":

  with only one chance in 10^{15} that it interacts at all.
  [Thanks to A. Teymourian, 4/10/2007]

- 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 186, just above Equation (6.98): The sentence in parentheses should't be there. [It would be true if $\nu_\mu \rightarrow \nu_e + \gamma$ were possible, and the states ν_e and ν_μ would not need to be orthogonal if $\mathrm{e} \rightarrow \mu + \gamma$ were possible, but as written it is certainly false.]

  Let $|\nu_1\rangle$ and $|\nu_2\rangle$ be the neutrino states with definite energy, normalized and orthogonal. Then
  [Thanks to T. Bodiya, 2/06/2005]

- Page 187: At some point I changed the sign of ω in about half the places it occurs, so that the argument became incomprehensible. Section 6.3 really needs to be rewritten, but several changes in this and the next three pages should fix it up: Just below Equation (6.100) change "In this basis" to "In Equation". In Equation (6.102) the middle expression should be preceded by a minus sign. At the end of the following sentence, change "$\omega\sigma_3$" to "$-\omega\sigma_3$". Just below Equation (6.104) change "In this basis" to "In Equation". In Equation (6.105), in the third expression delete the minus sign in the exponent, and in the last expression change minus to plus. In the line below Equation (6.105) change "$n_x = \sin 2\theta$" to "$n_x = -\sin 2\theta$". And in Equation (6.107) interchange "1" and "2" in the first two expressions:

  In Equation (6.100)...

  $$\omega = -\frac{1}{2}\mathrm{Tr}\ \big(\sigma_3 H\big) = \frac{E_2 - E_1}{2} \tag{6.102}$$

  E_o is an overall constant energy that has no observable consequences, so redefine the Hamiltonian to be a traceless matrix $H = -\omega\sigma_3$.....

  In Equation (6.104)...

  $$\psi(t) = \begin{pmatrix} \psi_{\nu_\mu}(t) \\ \psi_{\nu_\tau}(t) \end{pmatrix} = e^{-iHt}\psi(0) = e^{i\omega\hat{\boldsymbol{n}}\cdot\boldsymbol{\sigma}t}\psi(0) = \big[\cos\omega t + i\sin\omega t\,\hat{\boldsymbol{n}}\cdot\boldsymbol{\sigma}\big]\,\psi(0) \tag{6.105}$$

  where $n_x = -\sin 2\theta$, $n_y = 0$, and $n_z = \cos 2\theta$...

  $$E_2 - E_1 = \sqrt{p^2 + m_2^2} - \sqrt{p^2 + m_1^2} = \frac{\Delta m^2}{2p} + \cdots \tag{6.107}$$

  [1/27/2005]

- 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 189, Equation (6.104′): The last expression should be preceded by a minus sign:

$$H = -\omega\begin{pmatrix} \cos 2\theta & -\sin 2\theta \\ -\sin 2\theta & -\cos 2\theta \end{pmatrix} = -\omega\left[\cos 2\theta\sigma_3 - \sin 2\theta\sigma_1\right] \tag{6.104′}$$

  [Thanks to D. Matlock, 1/27/2005]

- Page 190: Change the last word on page 189 to "switch". The sentence fragment at the top of page 190 should read "identitles (and momentum) by exchanging a W^- boson." In the second line,"electroweak" is one word. The section referred to in the paragraph above Equation (6.119) should be "6.3.2". In that Equation (6.119) replace "H_m" by $(H_m)_{diag}$ and insert a minus sign before "ω_m".

  ...The ν_e and the electron can switch identities (and momentum) by exchanging a W^- boson. The amplitude for this term can be computed exactly from electroweak theory, and...

  The computation is identical to the one in Section (6.3.2)...

$$(H_m)_{diag} = -\omega_m\sigma_3 \tag{6.119}$$

  [1/27/2005]

- Page 190, in the sentence below Equation (6.122) replace $\pi/2$ with $\pi/4$:

  The formula for the mixing angle in matter has a maximum ($\theta_m = \pi/4$) when the denominator
  [Thanks to Y. Guo, 3/16/2006]

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

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

- Page 198, Problem 6.6: In the second equation, in the first term on the right-hand side, replace R_o with R_o^2:

$$H = \frac{L^2}{2MR_o^2} + \frac{\omega_o}{2}\hat{\boldsymbol{n}}(\phi)\cdot\boldsymbol{\sigma}$$

  [Thanks to A. Zhitnitski, 10/02/2004]

- Page 198, Problem 6.6: In the fourth equation, there should be a second equals sign before $\tan\theta$:

$$\frac{B_2}{B_1} = \frac{\omega_2}{\omega_1} = \tan\theta$$

[10/02/2004]

- 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 "$\mathbf{B} = B_o\hat{\boldsymbol{n}}_z + B_1$":

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

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

[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 "satisfiies":

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.:

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

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

- Page 204, two lines above Equation (7.17): This sentence should read:

  The solution to Equation (7.8) is not unique, since you can always add a solution of the homogeneous equation
  [Thanks to J. deGrassie, 1/26/2005]

- Page 204, Equation (7.18): $|\psi_m^o\rangle$ should be $|\psi_m\rangle$.

$$\langle\psi_n^o|\,\psi_m\rangle = \delta_{mn} \tag{7.18}$$

  [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 $\pm$:

$$\pm\Delta = \langle\psi_\pm|\,H'\,|\psi_\pm\rangle = \pm eE\langle 210|\,z\,|200\rangle \tag{7.38}$$

  [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.

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

  [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":

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

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

  [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 215, Equation (7.77): On the left, replace "V^2" by "$1/r^2$" and on the right, the numerator should be 1. In Equation (7.78), in the denominator, replace "α" by "a":

$$\left\langle \Phi_{jm}^{nl} \middle| \frac{1}{r^2} \middle| \Phi_{jm}^{nl} \right\rangle = \frac{1}{a^2 n^3 (l+\frac{1}{2})} \tag{7.77}$$

  the expectation value of V^2 is

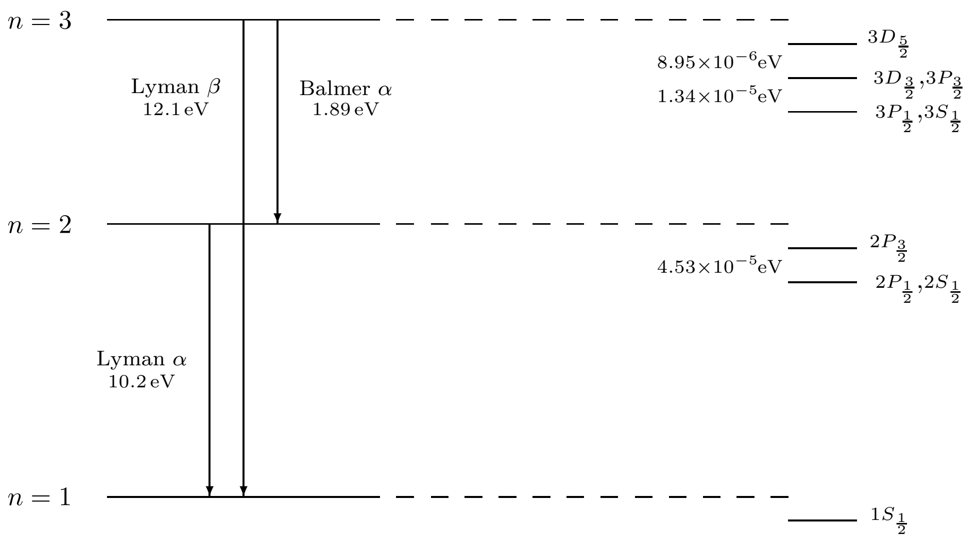
$$\left\langle \Phi_{jm}^{nl} \right| V^2 \left| \Phi_{jm}^{nl} \right\rangle = \frac{\alpha^2}{a^2 n^3 \left(l+\frac{1}{2}\right)} \tag{7.78}$$

  [2/02/2005]

- Page 216. Figure 7.3: replace "Balmer α" and "Balmer β" with "Lyman β" and "Balmer α" respectively.
  [Thanks to N. Kugland, 1/30/2006]

- Page 217, line below Equation (7.84): ψ should be ϕ:

  $L_z + 2s_z$ is not diagonal in the $\left|\phi_{jm}^{nl}\right\rangle$ basis, but its diagonal elements can be computed
  [Thanks to X. Han, 10/27/2004]



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

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

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

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

  [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:

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

  [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":

$$\begin{aligned}\Delta &= \frac{2}{3} \times \frac{1}{137.036^4} \times \frac{1}{1836} \times 2 \times 2 \times 2.78 \times 511,000\,\text{eV} \\ &\approx 5.9 \times 10^{-6}\,\text{eV}\end{aligned} \tag{7.105}$$

[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 "$R(a;r)$":

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

[2/09/2005]

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

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

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

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

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

[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.

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

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

- Page 227, second line below Equation (7.139): replace "is positive" with "is greater than the ground-state energy of a He^+ ion."

  the expectation value of the Hamiltonian is greater than the ground-state energy of a He^+ ion;
  [Thanks to Y. Guo, 3/15/2006]

- 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:

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

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

- Page 231, Equation (7.161): On the left, add "$d^n r$" (and also on the first line of Equation (7.165), and on the right, the second and third terms should begin with "+i":

$$\int \psi_o(\mathbf{r}, \mathbf{R})^* P_i^2 \psi_o(\mathbf{r}, \mathbf{R}) \phi(\mathbf{R}) d^n r = P_i^2 \phi(\mathbf{R}) + i A_i(\mathbf{R}) \boldsymbol{\nabla}_i \phi(\mathbf{R}) + i \boldsymbol{\nabla}_i A_i(\mathbf{R}) \phi(\mathbf{R}) \tag{7.161}$$

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

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

$$\int \psi_o(\mathbf{r}, \mathbf{R})^* \boldsymbol{\nabla}_i^2 \psi_o(\mathbf{r}, \mathbf{R}) \phi(\mathbf{R}) d^n r \tag{7.167}$$

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

- Page 232, Equation (7.169), on the right-hand side: Replace "$\mathbf{A}(\mathbf{R}) \cdot \mathbf{R}$" with "$\mathbf{A}(\mathbf{R}) \cdot d\mathbf{R}$"

$$\lambda(\mathbf{R}) = \int_{\mathbf{R}_o}^{\mathbf{R}} \mathbf{A}(\mathbf{R}) \cdot d\mathbf{R} \tag{7.169}$$

  [2/09/2005]

- Page 233, Equation (7.173): Replace "$2M$'' with "M" in the denominator in the first term on the right:

$$H_{\text{eff}} = \frac{\mathbf{P}^2}{M} + E_o^e(R) + U(R) \tag{7.173}$$

  [2/08/2006]

- 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 237, Equation (7.199): There is a "$\psi(x)$" missing at the end of the second term:

$$\psi''(x) + 2m\,[E - V(x)]\,\psi(x) = 0 \quad (7.199)$$

[Thanks to T. Butler, 2/14/2005]

- Page 238, in the paragraph between Equations (7.205) and (7.206): Change $S'(x)/S(x)$ to $S''(x)/S'(x)^2$:

the fractional change in wavelength over one wavelength should be small: $\left|S''(x)/S'(x)^2\right| \ll 1$.
[1/15/2006]

- Page 238, first paragraph of subsection 7.7.1, replace "$V(x) < a$" and "$V(x) > a$" respectively by "$V(x) < E$" and "$V(x) > E$":

Let a be a "turning point" of the classical motion, a point where $V(a) = E$, and suppose that $V(x)$ has a negative slope at $x = a$, so that $V(x) < E$ for $x > a$ and $V(x) > E$ for $x < a$.

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

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

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

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 242, Equation (7.236). x should be t:

$$\mathrm{Bi}(-t) = \sqrt{\frac{t}{3}}\left[J_{-\frac{1}{3}}\left(\frac{2}{3}t^{\frac{3}{2}}\right) - J_{+\frac{1}{3}}\left(\frac{2}{3}t^{\frac{3}{2}}\right)\right] \tag{7.236}$$

  [1/17/2006]

- Page 242, below Equation (7.239), replace "large positive x" with " $x \gg a$" and below Equation (7.240) replace "large negative x" with "$x \ll a$". In Equations (7.240) and (7.241), replace $(2m\beta)^{-1/6}$ by $(2m\beta)^{1/6}$. And in Equation (7.241) the lower and upper limits on the integrals should be x a respectively, and the minus sign belongs in the C_A term:[1]

  For $x \gg a$, this is

$$\psi(x) \underset{x\to+\infty}{\longrightarrow} \frac{1}{\sqrt{\pi}}(2m\beta)^{\frac{1}{6}}\frac{1}{\sqrt{k(x)}} \times\left[C_A\cos\left(\int_a^x k(x')dx' - \frac{\pi}{4}\right) - C_B\sin\left(\int_a^x k(x')dx' - \frac{\pi}{4}\right)\right] \tag{7.240}$$

  while for $x \ll a$, it is

$$\psi(x) \underset{x\to-\infty}{\longrightarrow} \frac{1}{\sqrt{\pi}}(2m\beta)^{\frac{1}{6}}\frac{1}{\sqrt{\kappa(x)}} \times\left[\frac{1}{2}C_A\exp\left(-\int_x^a \kappa(x')dx'\right) + C_B\exp\left(\int_x^a \kappa(x')dx'\right)\right] \tag{7.241}$$

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

- Page 243, Equations (7.243) and (7.244) replace $(2m\beta)^{-1/6}$ by $(2m\beta)^{1/6}$

$$C' = \frac{1}{\sqrt{\pi}}(2m\beta)^{\frac{1}{6}}C_A \qquad \text{and} \qquad D' = -\frac{1}{\sqrt{\pi}}(2m\beta)^{\frac{1}{6}}C_B \tag{7.243}$$

$$A = \frac{1}{\sqrt{\pi}}(2m\beta)^{\frac{1}{6}}C_B \qquad \text{and} \qquad B = \frac{1}{2}\frac{1}{\sqrt{\pi}}(2m\beta)^{\frac{1}{6}}C_A \tag{7.244}$$

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

[1] The form is not unique, but this choice makes all the integrals positive.

- 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 244, Equation (7.250), the lower limit of the integral should be b:

$$\psi(x) \approx \frac{A}{\sqrt{\kappa(x)}} \exp\left[-\int_b^x \kappa(x')dx'\right] \tag{7.250}$$

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

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

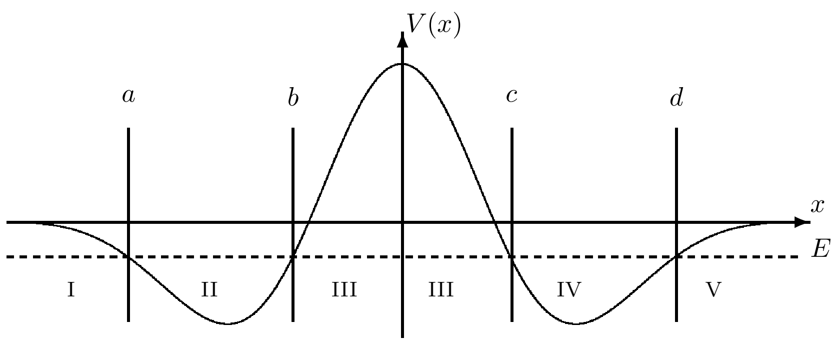


Figure 1: A double well potential illustrating the five separate WKB-approximation regions

  ....

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

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

- Page 249, Problem 7.4: “$\delta(x)$” is missing on the right-hand side of the equation:

$$H' = \beta E_o a \delta(x)$$

  [Thanks to A. Young, 2/08/2005]

- Page 251, Problem 7.8, Part (c), in the displayed equation there should a superscrtipt “2” after the partial derivative symbol in the numerator. And in the next to last line, “so” should be “to”:

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

> Hint: Be careful here. This is not a transformation of the quantum-mechanical states; the idea is to show that ....

[Thanks to C. Cooper, A. Goodhue, and N. Kugland, 2/14/2006]

- 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 252, Problem (7.8) part (d), just below the equation, replace "$V(\mathbf{r})/r_i^2$" with "$\partial^2 V(0)/\partial r_i^2$":

  and express a and b in terms of the constant c and $\partial^2 V(0)/\partial r_i^2$. What are the eigenvalues and...
  [Thanks to L. Fredrickson and E. Hemsing, 2/14/2005]

- Page 255, Problem 7.12, last line part (b): change "$m' = m = 1$" to "$m' = m = 0$"

  and choose $m' = m = 0$ and $i = j = 3$.
  [Thanks to Y. Wang, 3/20/2006]

- 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]

- Page 258, Problem 7.18: In the third and the last displayed equation, delete the minus sign:

  The magnetic perturbation is

  $$H_{\text{mag}} = \boldsymbol{\mu}\cdot\mathbf{B}$$

  .... Make a catalog of matrix elements of H_{mag}:

  $$\left\langle \psi^{nl}_{m_l m_s} \right| H_{mag} \left| \psi^{nl}_{m_l m_s} \right\rangle = \mu_B B(m_l + 2m_s)$$

  [Thanks to Y. Wang, 3/20/2006]

- Page 259, Problem 7.18, Part (e), second paragraph, second line: Delete the stray "f" after "$m = 1/2$":

  Take the basis to be the two $m = 1/2$ states, with $j = 3/2$ or $1/2$.
  [Thanks to E. Osoba, 3/21/2005]

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 :

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

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

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

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

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

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

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

  [2/15/2006]

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

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

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

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

- Page 270, Equation (8.38a): $2\pi^2$ should be $(2\pi)^{3/2}/4\pi$. And in Equation (8.40), on the bottom line, insert a minus sign after the first equals sign:

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

  ....

$$= -\frac{1}{2}\int_0^\infty r^2dr\int_{-1}^1 e^{iqr\cos\theta}U(r)d\cos\theta = -\frac{1}{q}\int_0^\infty r\sin(qr)U(r)dr \tag{8.40}$$

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

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

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

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

- Page 270, Equation (8.40): Change the left-hand side to $f^{(1)}(\Theta)$:

$$\begin{aligned} f^{(1)}(\Theta) &= -\frac{1}{4\pi}\int e^{i\mathbf{q}\cdot\mathbf{r}}U(\mathbf{r})\,d^3r \\ &= \frac{1}{2}\int_0^\infty r^2dr\int_{-1}^{1} e^{iqr\cos\theta}U(r)d\cos\theta = -\frac{1}{q}\int_0^\infty r\sin(qr)U(r)dr \end{aligned} \tag{8.40}$$

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

- 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, seventh line in the first paragraph: Replace "destructively" with "constructively":

That is the point where all the "wavelets" interfere constructively.
[Thanks to K. Lane, 2/14/2005]

- 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 $\hat{\boldsymbol{n}}$:

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

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

[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:

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

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

$$\text{Im}\,\psi^*\frac{\partial\phi}{\partial r} = -\text{Im}\,\psi\frac{\partial\phi^*}{\partial r} \tag{8.55}$$

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

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

- Page 273, Equation (8.56): In the second line, second term inside the large parentheses, move the asterisk from χ to ϕ. In the fourth line, first expression, second term inside the parentheses, change plus to minus:

$$\begin{aligned}\frac{k\sigma_{tot}}{(2\pi)^3} &= -\text{Im}\int\left(\phi^*(\frac{\partial\chi}{\partial r})+\chi^*(\frac{\partial\phi}{\partial r})\right)r^2d\Omega \\ &= -\text{Im}\int\left(\phi^*(\frac{\partial\chi}{\partial r})-\chi(\frac{\partial\phi^*}{\partial r})\right)r^2d\Omega \\ &= -\text{Im}\int\left(\phi^*(\frac{\partial\psi}{\partial r})-\psi(\frac{\partial\phi^*}{\partial r})\right)r^2d\Omega \\ &= -\text{Im}\int(\phi^*\boldsymbol{\nabla}\psi-\psi\boldsymbol{\nabla}\phi^*)\cdot\hat{\boldsymbol{n}}dS = -\text{Im}\int\left(\phi^*\boldsymbol{\nabla}^2\psi-\psi\boldsymbol{\nabla}^2\phi^*\right)d^3r \\ &= -\text{Im}\int\phi^*(r)U(r)\psi(r)d^3r = \frac{1}{2\pi^2}\text{Im}\,f(0)\end{aligned} \quad (8.56)$$

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

- Page 274, in the first line of Equation (8.60), and again in Eqation (8.62), replace ψ_{sc} with $d\psi_{sc}$. And on the first line of Equation (8.60) insert $f(\theta)$ to the left of the vertical bar.

$$d\psi_{sc} = 2\pi N dz\phi_o\,\frac{e^{ikr-\epsilon r}}{ik-\epsilon}f(\theta)\bigg|_{z_o}^{\infty} - 2\pi N dz\phi_o\frac{1}{ik-\epsilon}\int_{z_o}^{\infty}e^{ikr-\epsilon r}\frac{df(\theta)}{dr}\,dr \quad (8.60)$$

$$d\psi_{sc} \approx \frac{2\pi i N dz}{k}\phi_o e^{ikz_o}f(0) \quad (8.62)$$

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

- 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, Equation (8.97): Change the last r to r', and move the asterisk to after the second Y_l^m factor. In Equation (8.98), change the arguments of the first Y_l^m to (θ', ϕ'). In Equation (8.99) second line, change $\hat{\boldsymbol{n}}$ to θ', ϕ', and change $\hat{\boldsymbol{n}}_z$ to $0, \phi$:

$$\phi_{\mathbf{k}'}(\mathbf{r}') = \frac{4\pi}{(2\pi)^{\frac{3}{2}}} \sum_{l,m} i^l Y_l^m(\theta, \phi) Y_l^m(\theta', \phi')^* j_l(kr') \tag{8.97}$$

  and

$$\psi_{\mathbf{k}}(\mathbf{r}') = \frac{4\pi}{(2\pi)^{\frac{3}{2}}} \sum_{l,m} i^l Y_l^m(\theta', \phi')^* Y_l^m(0, \phi) R_l(r') \tag{8.98}$$

  Therefore the scattering amplitude is

$$\begin{aligned} f(\theta, \phi) &= -4\pi \int \left(\sum_{l,m} (-i)^l Y_l^m(\theta, \phi)^* Y_l^m(\theta', \phi') j_l(kr') \right) \\ &\times U(r') \left(\sum_{l'} i^{l'} Y_{l'}^o(\theta', \phi') R_{l'}(r') Y_{l'}^o(0, \phi) \right) r'^2 dr' d\Omega' \qquad (8.99) \\ &= -\int_0^\infty \left[\sum_l (2l+1) j_l(kr') U(r') R_l(r') P_l(\cos\theta) \right] r'^2 dr' \end{aligned}$$

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

- Page 280, Equation (8.100): On the left, k should be the denominator of all the rest, not just δ_l:

$$\frac{e^{i\delta_l} \sin\delta_l}{k} = -\int_0^\infty j_l(kr) U(r) R_l(r) r^2 dr \tag{8.100}$$

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

- 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 280, last sentence: Replace "in that number" by "in that limit".

  For small k there are only a few, and as $k \to 0$ only $l = 0$ survives. In that limit the scattering is characterized by a single number.
  [Thanks to M. Gutperle, 5/05/2004]

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

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

  [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 $k \to 0$ 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:

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

  [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:

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

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

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

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

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

  [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 $\rho(\mathbf{r}) = \left|\psi_{100}(\mathbf{r})^2\right|$, 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, Line 5: "23" should be just "3":

  ... the cross section at $k = 0$ would indeed be about $3 \times 10^{-24}\,\mathrm{cm}^2$.
  [3/09/2005]

- 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 subsubsection 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 $\hat{\varepsilon}$ is the polarization vector:
  [Thanks to D. Staszak, 6/08/2005]

- Page 289, Equation (9.10), second line: $4m^2$ in denominator should be just m^2.

$$\begin{aligned} P_b(t) &\approx |V_{ba}|^2 \left| \frac{e^{i(\omega_{ba}-\omega)t} - 1}{\omega_{ba} - \omega} \right|^2 \\ &= \frac{\alpha}{m^2} A_o^2 \left| \langle \psi_b | \, \mathbf{p} \cdot \hat{\varepsilon} e^{-i\mathbf{k}\cdot\mathbf{r}} \, | \psi_a \rangle \right|^2 \left| \frac{\sin(|\omega_{ba}| - \omega)t/2}{|\omega_{ba}| - \omega} \right|^2 \end{aligned} \tag{9.10}$$

  [5/11/2004]

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

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

- Page 290, Equation (9.14): Delete the "4" in the denominator.:

$$P(t) = \frac{\alpha}{m^2} \int_0^\infty \frac{8\pi}{\omega^2} \rho(\omega) \left| \langle \psi_b | \, \mathbf{p} \cdot \hat{\varepsilon} e^{-i\mathbf{k}\cdot\mathbf{r}} \, | \psi_n \rangle \right|^2 \left| \frac{\sin\left[(|\omega_{ba}| - \omega)t/2\right]}{|\omega_{ba}| - \omega} \right|^2 d\omega \tag{9.14}$$

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

- Page 290, Equation (9.16): Replace $4m^2$ by m^2 and $8\pi^2$ by $4\pi^2$.

$$P(t) \underset{t\to\infty}{\longrightarrow} \frac{\alpha}{m^2}\frac{4\pi^2}{\omega_{ba}^2}\rho(\omega_{ba})\left|\left\langle\psi_b\right|\mathbf{p}\cdot\hat{\boldsymbol{\varepsilon}}e^{-i\mathbf{k}\cdot\mathbf{r}}\left|\psi_n\right\rangle\right|^2 t \tag{9.16}$$

  [5/11/2004]

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

$$\left\langle\psi_b\right|\hat{\boldsymbol{\varepsilon}}\cdot\mathbf{p}e^{-i\mathbf{k}\cdot\mathbf{r}}\left|\psi_a\right\rangle \approx -im\hat{\boldsymbol{\varepsilon}}\cdot\langle\psi_b|\,[\mathbf{r},H_o]\,|\psi_a\rangle \tag{9.18}$$

  [5/11/2004]

- Page 291, Equation (9.17): Replace $4m^2$ by m^2 and $8\pi^2$ by $4\pi^2$.

$$\boxed{\Gamma_b = \frac{\alpha}{m^2}\frac{4\pi^2}{\omega_{ba}^2}\rho(\omega_{ba})\left|\left\langle\psi_b\right|\mathbf{p}\cdot\hat{\boldsymbol{\varepsilon}}e^{-i\mathbf{k}\cdot\mathbf{r}}\left|\psi_n\right\rangle\right|^2} \tag{9.17}$$

  [5/11/2004]

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

$$\left\langle\psi_b\right|\hat{\boldsymbol{\varepsilon}}\cdot\mathbf{p}e^{-i\mathbf{k}\cdot\mathbf{r}}\left|\psi_a\right\rangle \approx -im\hat{\boldsymbol{\varepsilon}}\cdot\langle\psi_b|\,[\mathbf{r},H_o]\,|\psi_a\rangle \tag{9.18}$$

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

- Page 291, in the line just above Equation (9.21): Change θ to $\cos^2\theta$. In Equation (9.21) change $\cos\theta$ to $\cos^2\theta$:

  where θ is the angle between the constant vector $\mathbf{r}$ and the polarization. If the radiation is unpolarized and isotropic, just replace $\cos^2\theta$ by its average value:

$$\cos^2\theta \to \frac{1}{4\pi}\int \cos^2\theta\, d\Omega = \frac{1}{3} \tag{9.21}$$

  [Thanks to K. Lane, 2/21/2004]

- Page 292, between Equations (9.25) and (9.26): Change the text to read: "Then $a_{ba}(t)$ is related to $A_{ba}(\omega)$ by"
  [Thanks to K. Lane, 2/18/2004]

- 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.

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

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

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

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

  [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 $G^o(\omega_a)$:

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

  [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:

$$\Gamma = \frac{d}{dt}P_{ba} = 2|T_{ba}(\omega_a)|^2\frac{\sin\left[(\omega_b-\omega_a)(t-t_o)\right]}{\omega_b-\omega_a} \underset{\substack{t\to\infty \\ t_o\to-\infty}}{\longrightarrow} 2\pi|T_{ba}(\omega_a)|^2\delta\left(\omega_b-\omega_a\right) \tag{9.67}$$

  [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:

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

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

- Page 304, Equation (9.90): Change the left hand side to $\langle \phi_b | T | \phi_a \rangle$:

$$\langle \phi_b | T | \phi_a \rangle = \delta_3 (\mathbf{K}' - \mathbf{K}) \langle \phi_b | \bar{T} | \phi_a \rangle \tag{9.90}$$

  [Thanks to K. Lane, 2/21/2004]

- Pages 304-305, In equations (9.90) through (9.95), and in the sentence below Equation (9.91), change T' to T everywhere.
  [Thanks to K. Lane, 3/01/2004]

- Page 304, Equation (9.93): The integrals should end in $d^3k_1' d^3k_2'$ and $d^3K' d^3k'$:

$$\begin{aligned} \bar{\Gamma} &= 2\pi \int |T_{ba}|^2 \delta(\omega_a - \omega_b) d^3k_1' d^3k_2' \\ &= 2\pi \int \left| \delta_3 (\mathbf{K}' - \mathbf{K}) \bar{T}_{ba} \right|^2 \delta(\omega_a - \omega_b) d^3K' d^3k' \\ &\approx 2\pi \int \left| \bar{T}_{ba} \right|^2 \delta(\omega_a - \omega_b) \delta_3 (\mathbf{K}' - \mathbf{K}) \frac{V}{(2\pi)^3} d^3K' d^3k' \end{aligned} \tag{9.93}$$

  [Thanks to K. Lane, 2/21/2004]

- 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 306, Equation (9.103). In the first line exchange $\mathbf{r}_1$ and $\mathbf{r}_2$ in the exponent. In the second line change the sign of the exponent:

$$\begin{aligned} H_{ba,2}' &= \pm \frac{1}{2} \frac{1}{(2\pi)^6} \int V(|\mathbf{r}_1 - \mathbf{r}_2|) e^{i(\mathbf{k}_2 - \mathbf{k}_1') \cdot \mathbf{r}_2} e^{i(\mathbf{k}_1 - \mathbf{k}_2') \cdot \mathbf{r}_1} \, d^3r_1 \, d^3r_2 \\ &= \pm \frac{1}{2} \frac{1}{(2\pi)^3} \int V(r) e^{i(\mathbf{k} + \mathbf{k}') \cdot \mathbf{r}} \delta_3 (\mathbf{K} - \mathbf{K}') \, d^3r \end{aligned} \tag{9.103}$$

  [Thanks to K. Lane, 3/01/2004]

- Page 307: In equation (9.104) delete the delta function $\delta_3(\mathbf{K}-\mathbf{K}')$ in the first line. Change T to $\bar{T}$ everywhere in (9.104) and (9.105). And replace p by k in these and the next two equations:

$$\begin{aligned}\bar{T}_{\text{direct}}(\omega_a,\theta,\phi) &= \frac{1}{(2\pi)^3}\int V(r)e^{i(\mathbf{k}-\mathbf{k}')\cdot\mathbf{r}}d^3r \\ &= \frac{e^2}{2\pi^2 q^2} = \frac{e^2}{4\pi^2 k^2(1-\cos\theta)} = \frac{\alpha}{8\pi^2 k^2\sin^2(\theta/2)}\end{aligned} \tag{9.104}$$

$$\begin{aligned}\bar{T}_{\text{exchange}}(\omega_a,\theta,\phi) &= \bar{T}_{\text{direct}}(\omega_a,\pi-\theta,\phi+2\pi) \\ &= \frac{e^2}{16\pi^2 k^2\cos^2(\theta/2)} = \frac{\alpha}{8\pi^2 k^2\cos^2(\theta/2)}\end{aligned} \tag{9.105}$$

$$\begin{aligned}\frac{d\sigma}{d\Omega} &= (2\pi)^4\mu^2\frac{\alpha^2}{64\pi^4k^4}\left|\frac{1}{\sin^2(\theta/2)} \pm \frac{1}{\cos^2(\theta/2)}\right|^2 = \frac{\alpha^2\mu^2}{4k^4}\left|\frac{1}{\sin^2(\theta/2)} \pm \frac{1}{\cos^2(\theta/2)}\right|^2 \\ &= \frac{\alpha^2\mu^2}{4k^4}\left(\frac{1}{\cos^4(\theta/2)} + \frac{1}{\sin^4(\theta/2)} \pm 2\frac{1}{\sin^2(\theta/2)}\frac{1}{\cos^2(\theta/2)}\right)\end{aligned} \tag{9.106}$$

$$\left(\frac{d\sigma}{d\Omega}\right)_{\text{unpolarized}} = \frac{\alpha^2\mu^2}{4k^4}\left(\frac{1}{\sin^4(\theta/2)} + \frac{1}{\cos^4(\theta/2)} - \frac{1}{\sin^2(\theta/2)}\frac{1}{\cos^2(\theta/2)}\right) \tag{9.107}$$

[3/20/2004]

- Page 307, Equation (9.105), in the second expression change $\phi+2\pi$ to $\phi+\pi$:

$$\bar{T}_{\text{exchange}}(\omega_a,\theta,\phi) = \bar{T}_{\text{direct}}(\omega_a,\pi-\theta,\phi+\pi) \tag{9.105}$$

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

- Page 309, Equation (9.112): Delete the integral sign:

$$\Gamma_{ba} = 2\pi|H'_{ba}|^2\delta(\omega_a-\omega_b) \tag{9.112}$$

[Thanks to A. Young, 4/26/2005]

- 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”:

$$+i\pi\sum_{b\neq a}|H'_{ba}|^2\delta(\omega_b-\omega_a) + \cdots\Bigg]^{-1} \tag{9.131}$$

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

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

- Page 312, Equation (9.132): On the left, change ω' to ω'_a. On the right, change the denominator to $\omega_b - \omega_a$. In Equation (9.133) replace ω by ω_b. In the text below Equation (9.134) delete "with $\omega'_a = \mathrm{Re}\,\omega'$ above":

$$\omega'_a = \omega_a + H'_{aa} + \mathrm{Re}\sum_{b\neq a} |H'_{ba}|^2 \frac{1}{\omega_b - \omega_a} + \cdots \tag{9.132}$$

$$-\pi \sum_{b\neq a} |H'_{ba}|^2 \delta\left(\omega_b - \omega_a\right) = -\Gamma/2 \tag{9.133}$$

$$G(\omega)_{aa} = \frac{1}{\omega - \omega'_a + i\Gamma/2} \tag{9.134}$$

Evidently $T(\omega)$ has a singularity in the lower half plane,
[3/20/2004]

- Page 313: The whole paragraph containing Equation (9.139) should be on the next page, at the end of Section 9.4.2.
[3/14/2005]

- 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)

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

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

- Page 314, just below Equation (9.142): Change "closer to" to "farther from":

which is farther from unity than the same probability
[Thanks to M. Gutperle, 5/16/2004]

- 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

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

....

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

[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 "$|H|'_{ba}$":

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

  [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]

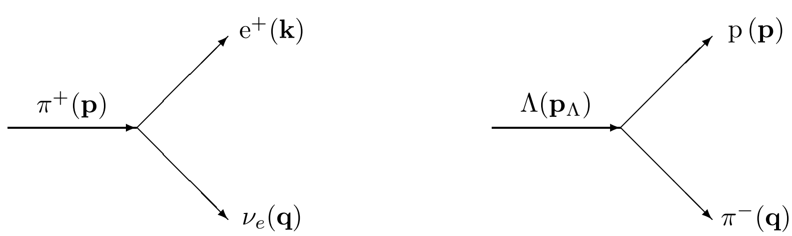
- Page 319, Problem 9.7, part (b): Change "masses of the two decay particles" to "masses of the three particles.":

  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 $\mathbf{p}_\lambda$ with $\mathbf{p}_\Lambda$:

  The initial state contains a Λ with momentum $\mathbf{p}_\Lambda$ and spin index m_Λ.
  [Thanks to J. May, 6/14/2005]

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



(a) (b)

  [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.

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

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

- Page 321, Problem 9.8, Part (c). Change "proprotional 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":

  k and **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 $\langle \boldsymbol{\sigma}_{\hat{\boldsymbol{n}}} \rangle/2$ 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 "$\langle\boldsymbol{\sigma}_{\hat{\boldsymbol{n}}}\rangle$", and include the boldface subscipt $\hat{\boldsymbol{n}}$ in the displayed formula:

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

[6/18/2006]

- Page 323, Problem 9.10, Part (c): replace "Λ polarization" with "proton spin":

  $F(\hat{\boldsymbol{n}})$ is some function of the proton direction, independent of the proton spin.
  [5/16/2005]

- Page 323, Problem 9.10, Part (c): In the unnumbered equation, replace "$\alpha+\beta+\gamma$" with "$\alpha^2+\beta^2+\gamma^2$":

$$\alpha^2+\beta^2+\gamma^2 = 1$$

  [5/05/2005]

Chapter X

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

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

  [5/30/2007]

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

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

  [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}:

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

  [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...

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

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

- Page 326, on the second line below Equation (10.16), change "positive" to "negative." In Equation (10.17), in the numerator of the exponent, change $\dot{q}^2$ to $\dot{q}_n^2$. And in Equation (10.18), second line, change q_n to q twice:

  A better way to evaluate them is continuing ϵ to a negative imaginary value

  .....

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

  .....

  $$= \int \mathcal{D}q \exp\left[i\int_{t_a}^{t_b} \left(\frac{m\dot{q}^2}{2} - V(q)\right) dt\right] \tag{10.18}$$

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

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

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

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

- Page 328, Equation (10.26): The final exponent should be inside the bracket instead of outside, and followed by dt. In Equation (10.31), in the first line, inside the large parenthesis, in the second term, delete the stray "t" in the numerator and in the denominator:

  $$K(q_b, t_b; q_a, t_a) = \exp\left(iS[q_o]\right) \int \mathcal{D}\delta q \exp\left[\frac{i}{2}\int_{t_a}^{t_b} \frac{\partial^2 L(\dot{q}_o)}{\partial \dot{q}^2} \delta\dot{q}(t)^2 dt\right] \tag{10.26}$$

  $$\begin{aligned} S[q] &= S[q_o] + \frac{1}{2}\int_0^{t_b} dt \left(\frac{\partial^2 L(\dot{q}_o)}{\partial \dot{q}^2} \left[\delta\dot{q}(t)\right]^2 + \frac{\partial^2 L(q_o)}{\partial q^2} \left[\delta q(t)\right]^2\right) \\ &= S[q_o] + \frac{m}{2}\int_0^{t_b} dt \left(\left[\delta\dot{q}(t)\right]^2 - \omega^2 \left[\delta q(t)\right]^2\right) \end{aligned} \tag{10.31}$$

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

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

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

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

- Page 329, Equation (10.38): In the second term interchange q and $\dot{q}$, and in the last term in the numerator, change ω^2 to ω.

$$\begin{aligned} S[q_o] &= \frac{m}{2}\int_0^{t_b}\left(\dot{q}(t)^2 - \omega^2 q(t)^2\right)dt = \frac{m\omega^2 Q^2}{2}\int_0^{t_b}\cos\left(2\omega t + 2\phi\right)dt \\ &= \frac{m\omega Q^2}{4}\left(\sin(2\omega t_b + 2\phi) - \sin 2\phi\right) \end{aligned} \tag{10.38}$$

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

- Page 330, Equation (10.41): On the second line, the minus sign should be inside the bracket, before $i\epsilon$, not before the integral sign. And on the third line, delete $\prod_{k=1}^{\infty}$ and dy_k:

$$\begin{aligned} I_N &\to \int \prod_{n=1}^{\infty} dy_n \exp\left[i\epsilon\frac{m}{2}\sum_{n=1}^{\infty}\left(\dot{y}_n^2 - \omega^2 y_n^2\right)\right] \\ &= \int \prod_{n=1}^{\infty} dy_n \exp\left[-i\epsilon\frac{m}{2}\sum_{n=1}^{\infty}\left(y_n\ddot{y}_n + \omega^2 y_n^2\right)\right] \end{aligned} \tag{10.41}$$

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

- Page 331, Equation (10.54): Replace 1/2 by $m/2$:

$$L_E = -L\left(q, i\frac{dq}{dw}\right) = \frac{m}{2}\left(\frac{dq}{dw}\right)^2 + V(q) \tag{10.54}$$

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

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

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

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

- Page 334, Equation (10.71): Replace dy with $\mathcal{D}y$, and insert 1/2 between the minus sign and the integral. And in Equation (10.74), in the exponent at the far right, replace $V''(0)T/2m$ with $\sqrt{V''(0)/m}T/2$:

$$K_E(q_b, T; q_a, 0) \approx \int \mathcal{D}y \exp\left[-\frac{1}{2}\int_0^T y(w)\left(-m\frac{d^2}{dw^2} + V''(0)\right)y(w)dw\right] \tag{10.71}$$

.....

$$\lim_{T\to\infty} K_E(q_b, T; q_a, 0) \approx K_o \frac{1}{\sqrt{\sinh V''(0)T/m}} \sim e^{-\sqrt{(V''(0)T/m)}/2} \tag{10.74}$$

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

- Page 335, Equation (10.77) in the line that begins with "×": 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 335, Equation (10.77): Insert $-i$ before the integrals on the last two lines:

$$\begin{aligned} &\to -i\int_0^{t_b} dt_1 \int_{-\infty}^{\infty} dq_1 K_o(q_b, t_b; q_1, t_1) V(q_1) K_o(q_1, t_1; q_a, 0) \\ &\to -i\int_{-\infty}^{\infty} dt_1 \int_{-\infty}^{\infty} dq_1 K_o(q_b, t_b; q_1, t_1) V(q_1) K_o(q_1, t_1; q_a, 0) \end{aligned} \tag{10.77}$$

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

- 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 337, Equation (10.90), second line: Change "$d\mathbf{r}$" to "$\dot{r}$":

$$\begin{aligned} K(\mathbf{r}_b, t_b; \mathbf{r}_a, t_a) &= \int \mathcal{D}\mathbf{r} \exp\left[i\int_{t_a}^{t_b} \big(L_o(\mathbf{r}, \dot{\mathbf{r}}) - e\mathbf{A}(\mathbf{r}, t)\cdot\dot{\mathbf{r}} + e\phi(\mathbf{r}, t)\big)dt\right] \\ &= \int \mathcal{D}\mathbf{r} \exp iS_o[\mathbf{r}] \exp\left[-ie\int_{t_a}^{t_b} \Big(\mathbf{A}(\mathbf{r}, t)\cdot\dot{\mathbf{r}} - \phi(\mathbf{r}, t)\Big)dt\right] \end{aligned} \tag{10.90}$$

[Thanks to N. Robles, 2/16/2005]

- Page 338, Equation (10.91a): Change $\mathbf{A}'(\mathbf{r})$ to $\mathbf{A}'(\mathbf{r}, t)$ In Equation (10.92), in the second line change "$d\mathbf{r}$" to "$\dot{r}$" here also, and in the third line add "dt" after "$\phi(\mathbf{r}, t)$":

$$\mathbf{A}(\mathbf{r}, t) \to \mathbf{A}'(\mathbf{r}, t) = \mathbf{A}(\mathbf{r}, t) + \boldsymbol{\nabla}\Lambda(\mathbf{r}, t) \tag{10.91a}$$

....
In the new gauge the propagator is

$$\begin{aligned} K'(\mathbf{r}_b, t_b; \mathbf{r}_a, t_a) &= \int \mathcal{D}\mathbf{r} \exp iS_o[\mathbf{r}] \\ &\times \exp\left[-ie\int_{\mathbf{r}_a}^{\mathbf{r}_b} \left(\mathbf{A}(\mathbf{r}, t)\cdot\frac{d\mathbf{r}}{dt} - \phi(\mathbf{r}, t) + \boldsymbol{\nabla}\Lambda(\mathbf{r}, t)\cdot\frac{d\mathbf{r}}{dt} + \frac{\partial}{\partial t}\Lambda(\mathbf{r}, t)\right) dt\right] \\ &= \int \mathcal{D}\mathbf{r} \exp iS_o[\mathbf{r}] \exp\left[-ie\int_{\mathbf{r}_a}^{\mathbf{r}_b} \left(\mathbf{A}(\mathbf{r}, t)\cdot d\mathbf{r} - \phi(\mathbf{r}, t)dt + \frac{d}{dt}\Lambda(\mathbf{r}, t)dt\right)\right] \\ &= K(\mathbf{r}_b, t_b; \mathbf{r}_a, t_a) \exp\left[ie\big(\Lambda(\mathbf{r}_a, t_a) - \Lambda(\mathbf{r}_b, t_b)\big)\right] \end{aligned} \tag{10.92}$$

[Thanks to N. Robles, 2/15/2005]

- 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.

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

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

- Page 340, Figure 10.1. The arcs should form a circle, whose center is at the base of the arrow. [Some glitch is a graphics program printed some of the arcs in the wrong place.]
  [7/31/2003]

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

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

  [6/07/2006]

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

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

  [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 $d\mathbf{R}$:

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

  ....

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

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

- Page 347, Equations (10.143) and (10.144): Delete the minus sign before the last term in both equations:

$$= \frac{1}{2B^2} \hat{\boldsymbol{n}}_z \tag{10.143}$$

  ......

$$\boldsymbol{\nabla} \times \mathbf{A}(\mathbf{B}) = \frac{\hat{\boldsymbol{B}}}{2|\mathbf{B}|^2} \tag{10.144}$$

  [Thanks to Y. Guo, 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.:

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

  [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:

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

....

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

  [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:

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

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

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

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

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

- Page 362, Equation (11.36), delete the "δ" preceding the last two integration symbols. Also, add "dt" at the end of both these integrals.

$$\begin{aligned}0=\delta\int_{t_1}^{t_2}L(t)dt&=\int_{t_1}^{t_2}\sum_\alpha\int\left[\dot{x}_\alpha(\mathbf{k},t)\delta\dot{x}_\alpha(\mathbf{k},t)-\omega^2x_\alpha(\mathbf{k},t)\delta x_\alpha(\mathbf{k},t)\right]d^3k\,dt\\&=\int_{t_1}^{t_2}\sum_\alpha\int\left[-\frac{d}{dt}\dot{x}_\alpha(\mathbf{k},t)-\omega^2x_\alpha(\mathbf{k},t)\right]\delta x_\alpha(\mathbf{k},t)d^3k\,dt\end{aligned} \tag{11.36}$$

  [Thanks to J. Ma, 4/17/2006]

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

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

  [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.

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

  and

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

  [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:

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

  [4/09/2007]

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

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

  [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 $a^\dagger_\alpha(\mathbf{k})^\dagger$ with $a^\dagger_\alpha(\mathbf{k})$:

$$\langle \gamma(\alpha,\mathbf{k}),00|\,\mathbf{p}\cdot\mathbf{A}(\mathbf{r})\,|1M\rangle \sim \left\langle \gamma(\alpha,\mathbf{k}),00\right|\hat{\boldsymbol{\varepsilon}}^*_\alpha(\mathbf{k})\cdot\mathbf{p}\,a^\dagger_\alpha(\mathbf{k})e^{-i\mathbf{k}\cdot\mathbf{r}}\left|1M\right\rangle \tag{11.106}$$

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

- Page 374, third line of last paragraph: Change “**p** and **r** and act” to “**p** and **r** act ”:

  be ignored in this argument, since **p** and **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 “Bs_e” with “$\mathbf{s}_e$”:

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

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

- Page 377, Equation (11.119): Replace 2^5 by 2^6, and therefore replace 9.49×10^{-31} by 1.87×10^{-30} and replace 1.44×10^{-15} by 2.84×10^{-15}. The the next line needs to read “The lifetime is 3.53×10^{14} seconds, over 100,000 centuries....”. Also, delete Equation (11.117e) – there is nothing there:

  The $J=0$ state is

$$\frac{\left|\frac{1}{2},-\frac{1}{2}\right\rangle-\left|-\frac{1}{2},\frac{1}{2}\right\rangle}{\sqrt{2}} \qquad M=0 \tag{11.117d}$$

$$\Gamma=\frac{2^6}{3^4}\alpha^{13}g_p^3(m/M)^3m=1.87\times10^{-30}\text{eV}=2.84\times10^{-15}\,\text{sec}^{-1} \tag{11.119}$$

  The lifetime is 3.53×10^{14} seconds, over 100,000 centuries. It should be clear
  [Thanks to K. Lane, 3/19/2004]

- Page 382, Equation (11.144): Insert the factor “$\delta\left(E_f+\omega-E_i\right)$” at the end:

$$\Gamma=\frac{\alpha}{2\pi m^2\omega}\int d^3k\sum_\alpha\left|\left\langle\psi_f\right|\hat{\boldsymbol{\varepsilon}}_\alpha(\mathbf{k})\cdot\mathbf{p}\,e^{i\mathbf{k}\cdot\mathbf{r}}\left|\psi_i\right\rangle\right|^2\delta\left(E_f+\omega-E_i\right) \tag{11.144}$$

  [4/26/2005]

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

$$\epsilon_i \epsilon_j^* \to \frac{1}{2} \int \sum_\alpha \hat{\boldsymbol{\varepsilon}}_{\alpha i}(\mathbf{k}) \hat{\boldsymbol{\varepsilon}}^*_{\alpha j}(\mathbf{k})\, d\Omega \Bigg/ \int d\Omega = \frac{\delta_{ij}}{3} \tag{11.147}$$

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

- Page 384, in Equation (11.164), inside the integral delete the factor $e^{i\omega \hat{\boldsymbol{n}}\cdot\mathbf{r}}$:

$$\frac{d\sigma(\omega)}{d\Omega_f} = \frac{4\pi^2 \alpha k_f}{m\omega} \frac{1}{\pi a^3} \frac{1}{(2\pi)^3} |\hat{\boldsymbol{\varepsilon}} \cdot \mathbf{k}_f|^2 \left| \int e^{-i\mathbf{q}\cdot\mathbf{r}} e^{-r/a}\, d^3 r \right|^2 \tag{11.164}$$

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

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

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

- Page 385, Equation (11.170): E_i should be E_o, and the exponent is $-7/2$:

$$\frac{d\sigma}{d\Omega_f} = 32\alpha \sin^2\theta a^2 \left(\frac{E_o}{\omega} \right)^{\frac{7}{2}} \tag{11.170}$$

  [Thanks to V. Teplitz, 4/20/2006]

- 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 $\hat{\boldsymbol{\varepsilon}}$ should be α, not γ:

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

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

......

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

[4/19/2006]

- Page 389, Equations (11.184) and (11.185), the subscripts of $\hat{\boldsymbol{\varepsilon}}$ should be α, not γ. And in Equation (11.186), third line: Change $\hat{\boldsymbol{\varepsilon}}^*_\alpha$ to $\hat{\boldsymbol{\varepsilon}}^*_{\alpha'}$:[2]

$$\frac{e^2}{4m^2}\sum_n \sum_{\gamma_1\gamma_2\gamma_3\gamma_4} \frac{4\pi}{(2\pi)^3}\frac{1}{2\omega}\delta_{\gamma_3\gamma}\delta_{\gamma_1\gamma_4}\delta_{\gamma_2\gamma_3}\delta_{\gamma_1\gamma'}$$
$$\times\left[\left\langle\psi_n\right|\mathbf{p}\cdot\hat{\boldsymbol{\varepsilon}}^*_{\alpha_4}(\mathbf{k}_4)e^{-i\mathbf{k}_4\cdot\mathbf{r}}\left|\psi_o\right\rangle\frac{1}{\omega+E_o-\omega_1-\omega_2-E_n}\left\langle\psi_o\right|\mathbf{p}\cdot\hat{\boldsymbol{\varepsilon}}_{\alpha_2}(\mathbf{k}_2)e^{i\mathbf{k}_2\cdot\mathbf{r}}\left|\psi_n\right\rangle\right]$$
$$=\frac{e^2}{4m^2}\sum_n\frac{4\pi}{(2\pi)^3}\frac{1}{2\omega}$$
$$\times\left[\left\langle\psi_n\right|\mathbf{p}\cdot\hat{\boldsymbol{\varepsilon}}^*_{\alpha'}(\mathbf{k}')e^{-i\mathbf{k}'\cdot\mathbf{r}}\left|\psi_o\right\rangle\frac{1}{\omega+E_o-\omega-\omega-E_n}\left\langle\psi_o\right|\mathbf{p}\cdot\hat{\boldsymbol{\varepsilon}}_{\alpha}(\mathbf{k})e^{i\mathbf{k}\cdot\mathbf{r}}\left|\psi_n\right\rangle\right] \tag{11.184}$$

.....

$$\times\sum_n\left\langle\psi_o\right|\hat{\boldsymbol{\varepsilon}}_\alpha\cdot\mathbf{p}e^{i\mathbf{k}\cdot\mathbf{r}}\left|\psi_n\right\rangle\frac{1}{E_{on}-\omega}\left\langle\psi_n\right|\hat{\boldsymbol{\varepsilon}}^*_{\alpha'}\cdot\mathbf{p}e^{-i\mathbf{k}'\cdot\mathbf{r}}\left|\psi_o\right\rangle \tag{11.185}$$

.....

$$=\frac{e^2}{m}\frac{4\pi}{(2\pi)^3}\frac{1}{\sqrt{4\omega'\omega}}\hat{\boldsymbol{\varepsilon}}^*_{\alpha'}\cdot\hat{\boldsymbol{\varepsilon}}_\alpha \tag{11.186}$$

[4/19/2006]

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

[2] There are similar corrections to the subscript of $\hat{\boldsymbol{\varepsilon}}^*$ on the next three pages also.

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

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

[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:

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

[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 $|\mathbf{n}|$:

$$\omega_\mathbf{n} = \frac{\pi}{L} |\mathbf{n}| \tag{11.218}$$

[4/26/2005]

- Page 399, Equation (11.230), last line: Change π^3 to π^2

$$= \frac{1}{2\pi} \left[\frac{6a}{\pi x^4} B_o + \frac{1}{12} B_4 \frac{\pi^3}{a^3} + \cdots \right]_{x=1/\omega_c} = \frac{3a\omega_c^4}{\pi^2} - \frac{1}{720} \frac{\pi^2}{a^3} + \cdots \tag{11.230}$$

[4/27/2005]

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

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

....

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

[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:

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

[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]

- Page 404, Problem 11.8, first line of Part (a): delete the factor $e^{i\mathbf{k}\cdot\mathbf{r}}$:

  (a) First convince yourself that the matrix element of $\mathbf{p}\cdot\mathbf{A}(\mathbf{r})$ indeed vanishes to all orders in the expansion of $e^{i\mathbf{k}\cdot\mathbf{r}}$.
  [Thanks to D. Staszak, 4/29/2005]

Chapter XII

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

$$z' = z \tag{12.14c}$$

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

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

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

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

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

$$\bar{R} = e^{-i\theta\hat{\boldsymbol{n}}\cdot\bar{\boldsymbol{J}}} \tag{12.20a}$$

$$\bar{B} = e^{-i\omega\hat{\boldsymbol{n}}\cdot\bar{\boldsymbol{K}}} \tag{12.20b}$$

  [1/04/2004]

- Page 410, Equations (2.21): The equations should be more general:

  where all the diagonal elements vanish, and

$$(\mathbf{J}_i)^0{}_j = (\mathbf{J}_i)^j{}_0 = 0 \tag{12.21a}$$

$$(\mathbf{J}_i)^j{}_k = -i\epsilon_{ijk} \tag{12.21b}$$

$$(\mathbf{K}_i)^j{}_k = 0 \tag{12.21c}$$

$$(\mathbf{K}_i)^j{}_0 = (\mathbf{K}_i)^0{}_j = i\delta_{ij} \tag{12.21d}$$

  [Thanks to J. May, A. Forrester, and others, 5/20/2006]

- Page 411, Equation (12.32): Insert an i before each summation symbol:

$$[X_i, X_j] = i\sum_k \epsilon_{ijk} X_k \qquad [Y_i, Y_j] = i\sum_k \epsilon_{ijk} Y_k \qquad [X_i, Y_j] = 0 \tag{12.32}$$

  [5/04/2005]

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

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

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

- Page 416, Equation (12.64): change $-qA^o$ to $+qA^o$:

$$\left[\frac{(\mathbf{p}+q\mathbf{A})^2}{2m} + qA^o\right]\phi(\mathbf{r}) = E'\phi(\mathbf{r}) + \frac{(E'-qA^o)^2}{2m}\phi(\mathbf{r}) \tag{12.64}$$

  [Thanks to Y. Guo, 5/24/2006]

- Page 416, Equation (12.66), replace $\mathbf{L}^2$ with $\mathbf{L}^2/r^2$:

$$\boldsymbol{\nabla}^2 = \frac{1}{r^2}\frac{\partial}{\partial r}r^2\frac{\partial}{\partial r} - \frac{\mathbf{L}^2}{r^2} \tag{12.66}$$

  [Thanks to S. Lake, 5/03/2006]

- Page 416, Equation (12.67): Change the sign of the last term inside the large parentheses from minus to plus:

$$\left(\frac{1}{2m}\frac{d^2}{dr^2} - \frac{l(l+1)-\alpha^2}{2mr^2} + \frac{\omega\alpha}{mr} + \frac{\omega^2-m^2}{2m}\right)u(r) = 0 \tag{12.67}$$

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

- 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 424, Equation (12.122) replace $D(\bar{K}_i)$ with $2D(\bar{K}_i)$:

$$\Sigma^{0i} = i\alpha_i = 2D(\bar{K}_i) \qquad \text{and} \qquad \Sigma^{ij} = \sum_k \epsilon_{ijk}\Sigma_k \tag{12.122}$$

  [Thanks to Y. Guo, 5/24/2006]

- Page 426, Equations(12.142). On the second line, change $\mathbf{p}^2/8m^2$ to $\mathbf{p}^2/4m^2$ and $\mathbf{p}^4/8m^2$ to $\mathbf{p}^4/8m^3$:

$$= \frac{1}{2m}\int \phi_1{}^\dagger(\mathbf{r})\left[1 - \frac{\mathbf{p}^2}{4m^2}\right]\mathbf{p}^2\phi_1(\mathbf{r})d^3r = \int \phi_1{}^\dagger(\mathbf{r})\left[\frac{\mathbf{p}^2}{2m} - \frac{\mathbf{p}^4}{8m^3}\right]\phi_1(\mathbf{r})d^3r \tag{12.142}$$

  [Thanks to F. O'shea, 5/20/2006]

- Page 427, Equation (12.148): In the denominator, replace r^2 with r^3:

$$\Delta_2 = \frac{\alpha}{2m^2}\int \phi_1{}^\dagger(\mathbf{r})\frac{1}{r^3}\mathbf{s}\cdot\mathbf{L}\,\phi_1(\mathbf{r})\,d^3r \tag{12.148}$$

  [Thanks to Y. Guo, 5/24/2006]

- Page 429, Equation(12.157): Change the sign of the last term:

$$\left(\frac{1}{2mr^2}\frac{\partial}{\partial r}r^2\frac{\partial}{\partial r} - \frac{1}{2mr^2}M + \frac{E\alpha}{mr} + \frac{E^2 - m^2}{2m}\right)\psi(\mathbf{r}) = 0 \tag{12.157}$$

  [5/15/2006]

- Page 429, Equation (12.162): On the right-hand side, there should be a "$2m$" in the denominator, and no m in the numerator

$$\frac{E^2 - m^2}{2m} = -\frac{E^2\alpha^2 m}{2m(n' + l' + 1)^2} \tag{12.162}$$

  [5/16/2005]

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

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

  [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:

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

  Then

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

  This is a one-particle state whose wave function is

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

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

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

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

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

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

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

  [5/18/2005]

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

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

  [5/17/2006]

- Page 441, Equation (13.28): On the right-hand-side, delete the minus sign before the first term:

  $$\begin{aligned} H = \frac{1}{2m} \int \boldsymbol{\nabla}\Psi^\dagger(\mathbf{r}) \cdot \boldsymbol{\nabla}\Psi(\mathbf{r}) d^3r & \\ + \frac{1}{2} \int v(\mathbf{r}_1, \mathbf{r}_2) \Psi^\dagger(\mathbf{r}_1)\Psi^\dagger(\mathbf{r}_2)\Psi(\mathbf{r}_1)\Psi(\mathbf{r}_2) d^3r_1 d^3r_2 & \end{aligned} \tag{13.28}$$

  [Thanks to D. Ramunno-Johnson, 5/18/2005]

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

$$H = \frac{1}{2m}\int \boldsymbol{\nabla}\Psi^\dagger(\mathbf{r})\cdot\boldsymbol{\nabla}\Psi(\mathbf{r})d^3r + \frac{1}{2}\int v_2(\mathbf{r}_1,\mathbf{r}_2)\Psi^\dagger(\mathbf{r}_1)\Psi^\dagger(\mathbf{r}_2)\Psi(\mathbf{r}_1)\Psi(\mathbf{r}_2)d^3r_1d^3r_2 \quad (13.28)$$

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

- Page 441, (Equation 13.30) and Page 442, Equation (13.31): In the denominators, change "*pi*' 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:

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

[5/18/2005]

- Page 442, Equation (13.37): Change "*pi*" 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 444, Equation (13.49), insert "$|\rangle$" after $b_j^\dagger$:

$$|i,j\rangle = b_i^\dagger b_j^\dagger|\rangle \qquad (i \neq j) \quad (13.49)$$

[Thanks to D. Staszak, 6/14/2005]

- Page 444, two lines above Equation (13.53), change "kT" to "$1/kT$":

the relative population of any two states is $\exp[\beta(E_{(n_1)} - E_{(n_2)})]$, where $\beta = 1/kT$.
[Thanks to A. Collette, 5/18/2005]

- Page 447, Equation (13.73). In each of the last two terms there is an extra b_i.

$$|\psi_o\rangle = \prod_i b_i^\dagger\Theta\left(E_F - \epsilon_i\right)|\rangle = \prod_i b_i^\dagger\Theta\left(p_F - |\mathbf{p}_i|\right)|\rangle \quad (13.73)$$

[Thanks to A. Tableman, 5/30/2006]

- 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 **r** to **k** (four times)

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

  [6/02/2005]

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

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

  [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:

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

  [5/31/2006]

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

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

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

  [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 $d_s^\dagger(\mathbf{k}) = b_{s+2}^\dagger(-\mathbf{k})$":

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

  ....

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

  but for the negative energy solutions

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

  [5/31/2006]

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

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

  ......

  [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:

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

  [6/02/2005]

- Page 464, in Equation (13.183), the second H should be H_o, and in Equation (13.187) on the left, $\bar{H}_{ba}$ should be H'_{ba}.

$$H = \int \mathcal{H}(x) d^3x = H_o + H' = \int \mathcal{H}_o(x) d^3x + \int \mathcal{H}'(x) d^3x \tag{13.183}$$

  ....

$$H'_{ba} = \delta_3\left(\mathbf{p}_1 + \mathbf{p}_2 - \mathbf{p}_3 - \mathbf{p}_4\right) \bar{H}'_{ba} \tag{13.187}$$

  [6/01/2006]

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

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

  [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: Problem 13.6 is garbled. The first full sentence after Equation (13.198) should be in part (b), and the next sentence should be omitted. Also, the first sentence after (13.199) should be omitted:

  (a) Compute the single particle correlation function

$$C_r(|\mathbf{r} - \mathbf{r}'|) = \left\langle N_o \right| \Psi_r^\dagger(\mathbf{r}) \Psi_r(\mathbf{r}') \left| N_o \right\rangle$$

as a function of ρ, p_F, and the distance $|\mathbf{r}-\mathbf{r}'|$.
(b) For the same state, work out the pair correlation function

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

Work out the cases $r = s$ and $r \neq s$ separately. Show that for equal spins, this correlation function vanishes as $\mathbf{r} \to \mathbf{r}'$. At what separation does the correlation function first reach a maximum?

[5/28/2006]

- 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:

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

[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 $Y_{l'}^{m'}$:

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

They are conventionally normalized on the unit sphere so that

$$\int Y_l^m(\theta,\phi)^* Y_l^m(\theta,\phi)d\Omega = 1 \qquad \text{(A.104)}$$

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

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

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

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

- Page 484, Equation (A.109): There should be a factor $1/2^l l!$ in front of the last two terms:

$$\frac{d^2}{d\rho^2}\left[\rho h_l^{(1)}(\rho)\right] = \left[\frac{l(l+1)}{\rho^2} - 1\right]\rho h_l^{(1)}(\rho) + 2i(l+1)\frac{\rho^l}{2^l l!}\int_1^{1+i\infty} z e^{i\rho z}(1-z^2)^l dz$$
$$+ \frac{\rho^{l+1}}{2^l l!}\int_1^{1+i\infty} e^{i\rho z}(1-z^2)^{l+1} dz \qquad \text{(A.111)}$$

[Thanks to E. Brown, 2/13/2007]

- 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":

$$\boldsymbol{\nabla}_{q_i} = \frac{1}{h_i} \frac{\partial}{\partial q_i} \tag{A.158}$$

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

- Page 494, Equation (1.166): A factor "r^2" is missing from the denominators in the last two terms:

$$\boldsymbol{\nabla}^2 f(\mathbf{r}) = \frac{1}{r^2}\frac{\partial}{\partial r} r^2 \frac{\partial f}{\partial r} + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}\sin\theta \frac{\partial f}{\partial \theta} + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 f}{\partial \phi^2} \tag{A.166}$$

[Thanks to M. Mecklenberg, 11/16/2005]

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

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

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

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

and in spherical coordinates,

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

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

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

[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): $d^{(j)}_{-q,q}$ should be $d^{(j)}_{-q,q}(\pi)$:

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

  [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]