Errata for Quantum Mechanics

by Ernest Abers

Intermediate Level Errata as of July 1, 2007 (1st and 2nd printings)

Chapter I

- 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, 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 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]

Chapter II

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

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

  [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]

Chapter III

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

Chapter IV

- 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 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 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

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

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

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

$$\mathbf{J}_i \cdot \mathbf{J}_i |\psi_{m_1 m_2 m_3}\rangle = j_i(j_i + 1)|\psi_{m_1 m_2 m_3}\rangle$$

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

Chapter V

- 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, 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 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 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 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 183, Equation (6.81): Change "**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, in the paragraph below Equation (6.84): Replace "$\mathbf{H}'$" with "**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 **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 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 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 $\tan\theta$:

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

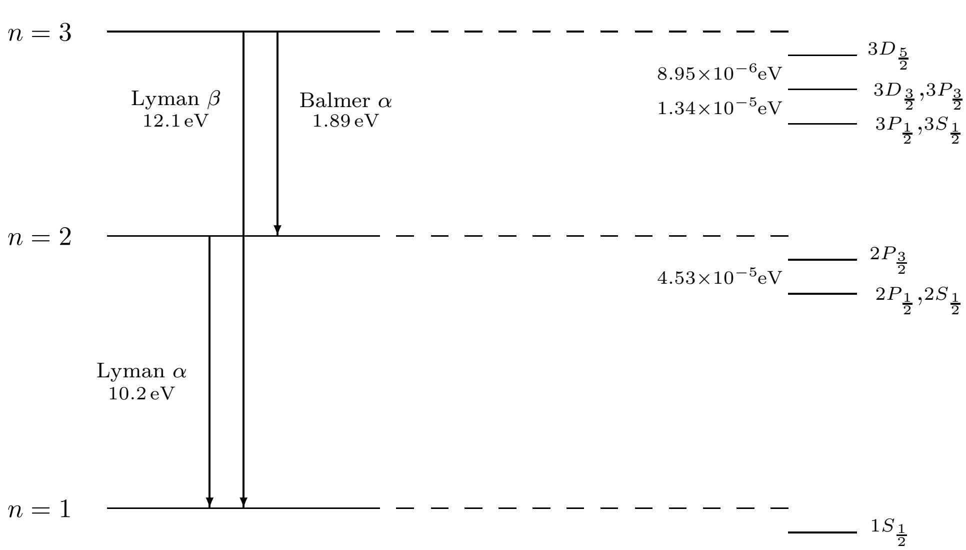
[10/02/2004]

Chapter VII

- 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 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 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":

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

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

- Page 232, Equation (7.169), 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 237, Equation (7.199): There is a "$\psi(x)$" missing at the end of the second term:

$$\psi''(x) + 2m\left[E - V(x)\right]\psi(x) = 0 \tag{7.199}$$

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

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

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

  [1/17/2006]

- Page 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 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 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 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:

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

....

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

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

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

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

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

- Page 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.

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

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

[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]

Chapter IX

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

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

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

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

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

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

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

$$\Gamma_{ba} = 2\pi |H_{ba}'|^2 \delta(\omega_a - \omega_b) \qquad (9.112)$$

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

- 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 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]

Chapter X

- 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 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 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 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 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

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

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

- Page 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]

Chapter XI

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

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

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

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

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

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

- Page 389, Equations (11.184) and (11.185), the subscripts of $\hat{\varepsilon}$ should be α, not γ. And in Equation (11.186), third line: Change $\hat{\varepsilon}^*_\alpha$ to $\hat{\varepsilon}^*_{\alpha'}$:[1]

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

.....

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

.....

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

[4/19/2006]

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

where all the diagonal elements vanish, and

$$(\mathbf{J}_i)^0{}_j=(\mathbf{J}_i)^j{}_0=0 \tag{12.21a}$$
$$(\mathbf{J}_i)^j{}_k=-i\epsilon_{ijk} \tag{12.21b}$$
$$(\mathbf{K}_i)^j{}_k=0 \tag{12.21c}$$
$$(\mathbf{K}_i)^j{}_0=(\mathbf{K}_i)^0{}_j=i\delta_{ij} \tag{12.21d}$$

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

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

- 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 (12.67): 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 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]

Chapter XIII

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

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

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

- Page 444, Equation (13.49), insert "$|\rangle$" after $b_j^\dagger$:

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

[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 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]

Appendix

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

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

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

- 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]