Errata: Typographical Errors, Mistakes, and Comments
Modern Quantum Mechanics, 2nd Edition
Second Printing
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Page 2. *Figure 1.1.* The figure has the north pole on top and the south pole below, reversed from the analogous figure in the Revised Edition. The text on page 3 needs to be modified.

Page 5. *Figure 1.3.* The dotted lines labeled "S_x- beam" and "S_z- beam" should be solid lines instead. The dotted line labeled "No S_z- comp." in the uppermost drawing can stay.

Page 28. *Equation (1.4.20).* I don't see where it is explicitly stated that there is an implied summation over the index $k = 1, 2, 3$.

Page 34. *Equation (1.4.57).* There is an errant right parenthesis in the second term. The term should be $|\langle\alpha|\beta\rangle|^2$.

Page 35. The equation (1.4.63) needs a comma in the anti-commutator in the second term on the right.

Section 1.7. It seems that a discussion of the boost operator $B(\Delta p')$ should be included, that is $B(\Delta p')|p'\rangle = p'|p'\rangle$. One could introduce a generator G in the usual way, that is $B(dp') = 1 - iGdp'/\hbar$, and follow the discussion to obtain the momentum space representation of the position operator. Much could be left as a problem.

Page 57. The left side of Equations (1.7.45) should read $\langle\mathbf{x}'|\mathbf{x}''\rangle$ and $\langle\mathbf{p}'|\mathbf{p}''\rangle$.

Page 58. *Problems 1.2 and 1.3.* The Pauli matrices $\boldsymbol{\sigma}$ are not defined in Chapter One. See (3.2.32). Perhaps these problems should be moved to Chapter Three.

Page 59. *Problem 1.5(b).* The state notation is inconsistent with what is used in the text. That is, $|s_z = \hbar/2\rangle$ should be written as $|S_z;+\rangle$, and $|s_x = \hbar/2\rangle$ should be written as $|S_x;+\rangle$.

Page 60. *Problem 1.11.* The hint would appear to be misplaced, referring essentially to the solution of Problem 1.9, the connection is peculiar. Following that hint can help you solve the problem, but would nonetheless be confusing. I think the hint should just be scrapped.

Page 60. *Problem 1.12.* This problem is a special case of Problem 1.9, and with different notation for the angles. It would make sense to combine it with Problem 1.9.

Page 63. *Problem 1.24.* See (3.2.32) for a definition of $\sigma_x \equiv \sigma_1$.

Page 75. *Equation (2.1.60).* For notational consistency, the bra on the left side of the start of the equation should be $\langle S_x;\pm|$.

Pages 78–80. The section on **Correlation Amplitude and the Energy-Time Uncertainty Relation** does not seem to flow well from the material ahead of it in this section.

Page 113. *Figure 2.5.* There are lots of things wrong with this figure. It has inflection points at the wrong places (they should be at the turning points) and the amplitude and wavelength should both decrease towards the center of the well. There's also no reason to imply that the well should be parity symmetric.

Page 122. The "awkward" expression written as

$$x'''' \underset{N\text{ times}}{\cdots} x'''$$

looks to me like it should have been written instead as something like $x^{''''\cdots\ (N\text{ times})}$.

Page 140. Just beneath (2.7.55), $\boldsymbol{\nabla}(\mathbf{x}')$ should be $\Lambda(\mathbf{x}')$.

Pages 141–143. There are some things to say about the problem discussed in relation to Fig. 2.11. Firstly, one should be referred to Problem 2.28 which completes the calculation and applies it to the notion of quantized magnetic flux. More importantly, though, it seems that an essential point is missing from the discussion. We need to insist that the potential (2.7.62) is used (for $\rho \geq \rho_a$) for the case $\mathbf{B} \neq 0$. To put $\mathbf{A} = 0$ for $\rho \geq \rho_a$ would imply a radial discontinuity at the boundary, leading to an unphysical infinite $\mathbf{B}$ since $\mathbf{A}$ grows linearly with ρ for $\rho \leq \rho_a$. But you can "gauge away" (2.7.62) and use the solution to the $\mathbf{B} = 0$ problem instead, albeit with the phase factor (2.7.55) applied to the wave function.

Page 148. A problem should be added that treats the linear potential (2.5.30) through Schrödinger's equation in momentum space.

Page 150. *Problem 2.11.* This problem is rather open ended, atypical for most of the problems in the book. Perhaps it should be revised. Most of the problem is in fact covered on pages 94 to 96.

Page 151. *Problem 2.12.* Not enough information is given in the problem statement. The state $|0\rangle$ is one for which $\langle x\rangle = 0 = \langle p\rangle$.

Page 151. *Problem 2.14.* Evaluating $\langle m|\{x,p\}|n\rangle$ is rather tedious and, to my knowledge, not particularly enlightening or useful. It could be removed. Also, it is worth stating the virial theorem here for convenience. That is

$$\left\langle \frac{\mathbf{p}^2}{m} \right\rangle = \langle \mathbf{x}\cdot\boldsymbol{\nabla}V\rangle \qquad \text{in 3D, or} \qquad \left\langle \frac{p^2}{m} \right\rangle = \left\langle x\frac{dV}{dx} \right\rangle \qquad \text{in 1D}$$

Page 152. *Problem 2.19.* There is a lot to say about this problem.

- The problem is really about quantum optics. See the end Chapter Seven of the textbook. (This section should be expanded in future editions.) Also see R. J. Glauber, Phys.Rev.84(1951)395 and his Nobel lecture in Rev.Mod.Phys.78(2006)1267; Gottfried 1966, Sec.31; Merzbacher 1998, Sec.10.7; and Gottfried 2003, Sec.4.2.
- It should be stated that $P_n(\mu) = e^{-\mu}\mu^n/n!$ is the Poisson distribution of integers n with a mean μ. Note that the "most probable" value of n is an integer.
- Part **(d)** includes a reference to Gottfried 1966, 262–264. This is for a theorem (which Gottfried 2003 calls the Baker-Campbell-Hausdorff theorem) needed to solve it, namely that $e^{A+B} = e^A e^B e^{-[A,B]/2}$ for any two operators A and B which commute with $[A,B]$. See also Problem 2.13 in Gottfried 2003, and Equation 39 in Glauber 1951.

Page 152. *Problem 2.20.* This problem borrows definitions from Chapter 3, and in fact provides some of the background for Section 3.9, but a proper definition of $\mathbf{J}^2$ is not provided up to this point. Given the context of this problem, it is probably best to explicitly add the definition of $\mathbf{J}^2$ as given in the first line of (3.9.12), namely

$$\mathbf{J}^2 \equiv J_z^2 + \left(\frac{1}{2}\right)(J_+J_- + J_-J_+)$$

Page 153. *Problem 2.23.* The problem does not appear to be well-posed. From the existing solutions manual, I gather that "known to be exactly at $x = L/2$ with certainty" means that the wave function is proportional to $\delta(x-L/2)$, but this does not appear to be normalizable. I would suggest dropping this problem in future editions.

Page 153. *Problem 2.25.* I think there is nice physics in this problem, but neither the presentation nor the solution manual are enlightening. First, it should be combined with problem 24, and the notation made the same. The (negative) energy eigenvalue for $t < 0$ is unphysical for $t > 0$, so the answer needs to be expanded in terms of positive energy states. I want to study this more before deciding how to rewrite the problem, and the solution.

Page 154. *Problem 2.27.* The second sentence "Your answer…in two dimensions" can be deleted. This problem is held over from the Revised Edition, but the Second Edition explicitly covers the density of states in three dimensions in this chapter.

Pages 154, 155. The old solutions manual gives answers for Problems 2.31 through 2.35 for which I am not entirely clear. I suspect that the next revision will see these problems, and also Section 2.6, significantly reworked.

Page 156. *Problem 2.40.* In the formula one is asked to derive, ΔB is not defined and should simply be B, and $\bar{\lambda}$ should be "λ-bar", i.e. $\lambda/2\pi$.

Page 156. *Problem 2.40.* The cryptic quote about publishing the solution in Physical Review Letters in 1967 is likely referring to H. Bernstein, Phys.Rev.Lett. 18(1967)1102.

Page 164. The piece "*Derivation 2*" is misplaced in this section. This calculation should be done in Section 3.1 to demonstrate that the result is not specific to spin-1/2. In fact, I would leave "*Derivation 1*" to a problem at the end of the chapter.

Page 164. *Equation (3.2.7).* There is an extra component in the commutator of the second term on the second line. That is, it should read $[S_z, [S_z, [S_z.S_x]]]$, not $[S_z, [S_z, [S_z, [S_z.S_x]]]]$.

Section 3.3. This section interrupts the flow of the book and needs surgery. The material under **Orthogonal Group** and **Unitary Unimodular Group** is good, but should be moved to Sec. 4.1, preceding the discussion on **SO(4) Symmetry in the Coulomb Potential** and merged otherwise into the new section. The material on **Euler Rotations** is probably best moved into Sec. 3.5, either within or preceding under **Representations of the Rotation Operator**.

Section 3.4. I don't think this section belongs in Chapter 3. It would fit more naturally as the third section of Chapter 2, perhaps with an extended discussion, or new section, on **Quantum Statistical Mechanics** including ties to the material on page 220.

Page 194. *Equation (3.5.33).* There is a missing − sign. It should read $m = -j, -j+1, \ldots$.

Pages 208-209. One of my favorite lessons from Dirk Walecka is the physical reasoning that allows one to eliminate the solutions $u(r) \propto r^{-l}$. In my haste to get to the physics, though, I neglected to include the spherical harmonic factors in (3.7.13). Of course, integrating over the sphere removes the angular dependence, and the result is the same.

Page 219. I think it may be more instructive to explicitly carry out the diagonalization of $\mathbf{S}^2$ in the $|++\rangle$, $|--\rangle$, $|+-\rangle$, $|-+\rangle$ basis. The last paragraph of the section ends with

"The reader is encouraged to work out all this in detail." I'm not sure that many will follow that advice, and it would be good to emphasize the key points.

Page 224. The sum in (3.8.43) should just be over either m_1 or m_2 since their sum is fixed.

Page 224. *Equation (3.8.45).* The operators $J_{1\pm}$ and $J_{2\pm}$ just to the left of the summation should be capitalized.

Page 227. There are some problems here. First, two errors were made in transcribing to the Second Edition from the Revised Edition. Just above (3.8.54), the text should refer to (3.8.49) instead of (3.7.49). Also, the second factor in the square root in the bottom part of (3.8.54) should be $(l - m + 1/2)$ instead of $(l - m - 1/2)$. These changes, then, correctly lead to (3.8.56). I am unable, however, to derive (3.8.54) from (3.8.49), as m seems to be confused with $m + 1$. I will need to look into this subsection further.

Page 229. *Equation (3.8.64).* In the second term, on the second line of the equation, the numerator under the square root in the factor in front of $Y_l^{m+1/2}(\theta, \phi)\chi_-$ should be $l \mp m + 1/2$ instead of $l \pm m + 1/2$. It is corrected in the third line.

Page 234. *Equation (3.9.13c).* Remove the errant "," to get $(n_+ - n_-)$.

Page 245. The first sentence of the last paragraph had some errant words added at the proofing stage. It should read "It might be thought that A and B can communicate if one of them suddenly changes the orientation of his or her analyzing apparatus."

Page 246. *Equation (3.11.5).* Subscript error. There first symbol V_t should be V_i.

Page 246. In my class, it works better to carry through the discussion of **Vector Operator** all the way to the Wigner-Eckart Theorem analogy, i.e. for $k = 1$. This can be done just by continued manipulation of the commutation relations, and takes some of the mystery out in the discussion of irreducible spherical tensor operators.

Page 249. *Equation (3.11.22a).* The rotation operator in the sum on the right hand side should have an argument R.

Page 249. There is a subtlety, I think, which is not clear from the text. Note that in the line just before (3.11.23), the infinitesimal form of (3.11.22b) is referenced, but it looks like the sign is wrong. In fact, this is a *passive* rotation of the coordinate axes, so $\hat{\mathbf{n}}$ is opposite of what we normally expect.

Page 251. The end of the paragraph at the bottom of the page would be clearer if it were written as "$k_{1,2} \to j_{1,2}$ and $q_{1,2} \to m_{1,2}$."

Page 252. Just before (3.11.29) in the text, it should read $T_q^{(k)}|\alpha, jm\rangle$ instead of $T_q^{(\kappa)}|\alpha, jm\rangle$.

Page 253. *Equation (3.11.33).* The matrix element should read $\langle\alpha', j'm'|T_{q\pm1}^{(k)}|\alpha, jm\rangle$.

Page 255. I should add a problem or two to this chapter having to do with normalized eigenfunctions of the isotropic 3D harmonic oscillator.

Page 256. *Problem 3.7.* I don't understand this problem. Either that, or it is trivial. The original solution manual doesn't clear things up for me, either.

Page 257. *Problem 3.15.* I see no good reason to write the equation in (**b**) as if the J_- operators acts on a wave function.

Page 258. *Problem 3.19.* Spherical harmonics are written as $Y_{l,m}(\theta,\phi)$ instead of $Y_l^m(\theta,\phi)$ as they are in the body of the text. I need to go through all instances and make sure that the nomenclature is consistent.

Page 259. *Problem 3.21.* Part **(c)** should say $|qlm\rangle = |100\rangle$, i.e. the second excited state with $q = 1$ and $N = 2$. **Also**, now having assigned this problem in class, it's clear that the problem is too long and difficult for most students. Maybe add parts to the text, and then more guidance to work through the problem. Also a good place to prove that energy degeneracy means we only expand over degenerate states.

Page 259. *Problem 3.22.* The problem is incomplete; there is a step missing. Part **(e)** should be included which defines the "Associated" Laguerre polynomials as

$$L_n^k(x) = (-1)^k \frac{d^k}{dx^k}\left[L_{n+k}(x)\right]$$

and then asks to show that they satisfy the differential equation

$$xL_n^{k\prime\prime}(x) + (k+1-x)L_n^{k\prime}(x) + nL_n^k(x) = 0$$

which in fact can be shown to be Kummer's equation. That is, the hydrogen atom radial wave functions are expressed in terms of *associated* Laguerre polynomials, as opposed to Laguerre polynomials.

Page 259. *Problem 3.24.* This is a good problem, but I would reword it as follows: Find all nine states $|j,m\rangle$ for $j = 2$, 1, and 0 formed by adding $j_1 = 1$ and $j_2 = 1$. Use a simplified notation, where $|j,m\rangle$ is explicit and $\pm, 0$ stand for $m_{1,2} = \pm1, 0$, respectively, for example

$$|1,1\rangle = \frac{1}{\sqrt{2}}|+0\rangle - \frac{1}{\sqrt{2}}|0+\rangle$$

You may also want to make use of the ladder operators $J_\pm$, or recursion relations, as well as orthonormality. Check your answers by finding a table of Clebsch-Gordan coefficients for comparison. *(I should probably include such a table in future editions of the book.)*

Page 260. *Problem 3.27.* I think this problem should be deleted. I don't know what is meant by $|jmn\rangle$, and the solution manual's answer, although simple, is unenlightening.

Page 261. *Problem 3.32(a).* This is better written as "Write xy, xz, and $(x^2 - y^2)$ in terms of components of a..."

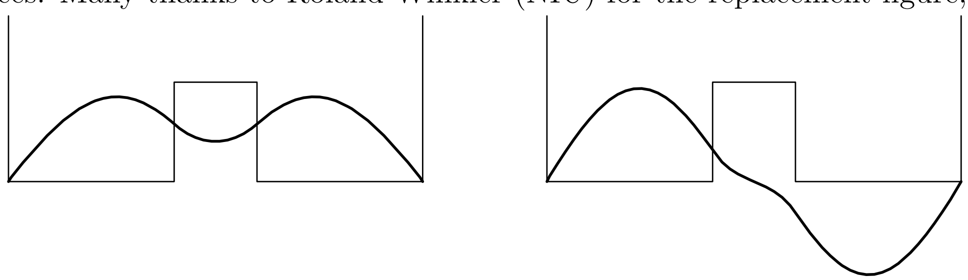
Page 265. This method of solving the hydrogen atom was first worked out by Pauli, in Zeitschrift Phys., **33**(1925)879. An English translation "On the hydrogen spectrum from the standpoint of the new quantum mechanics", is published in *Sources of Quantum Mechanics*, B. L. Van der Waerden, Dover (1967). Many thanks to Djordje Minic for pointing me to this reference.

Page 265. Regarding the classical treatment of the Runge-Lenz vector, I should have referred the reader to Goldstein, Poole, and Safko (2002) section 3.9.

Page 265. I goofed, and should have used $\mathbf{x}$ instead of $\mathbf{r}$ in (4.1.19) and (4.1.20)..

Page 274. Beware the subtlety in the relation (4.2.33). It looks as if there are indeed *two* parity eigenstates, one positive and the other negative. However, the end of the proof shows that $|n\rangle$ and (4.2.33) are the same state, for either the + sign or the − sign, but not both. In the case of the wrong sign, (4.2.33) just gives zero.

Page 275. Figure 4.3 is poorly drawn, with the curvatures and inflection points in the wrong places. Many thanks to Roland Winkler (NIU) for the replacement figure, below:



Page 282. Beware that (4.3.12) is not a normalized ket. In fact

$$\langle\theta|\theta\rangle = \sum_{n=-\infty}^{\infty}\sum_{m=-\infty}^{\infty} e^{i(n-m)\theta}\langle m|n\rangle = \sum_{n=-\infty}^{\infty}(1)$$

Section 4.4. I think the beginning of this section works better if one *first* arrives at (4.4.26) and discusses the inconsistencies it presents, *then* show how complex conjugation also has something to do with the wave equation (4.4.4), *next* present the concept of an antilinear operator as in (4.4.13b), and *finally* come around to the antiunitary operator as in (4.4.13a).

Page 290. *Figure 4.12.* In (a) the arrow next to "Momentum before reversal" should in fact be attached to "Momentum after reversal." That is, both arrows should come from "after" while "Momentum before reversal" just labels the rightward arrow at $t = 0$. Indeed, the labeling in the corresponding Figure 4.11 in the Revised Edition is a bit ambiguous.

Page 292. Using $\otimes$ for a generic operator is confusing. It is probably better to just use X.

Page 297. The statement that (4.4.75) "is evident from the properties of angular momentum..." is too cavalier. The phase factor $(-1)^{2j}$ is not obvious for all j. However, it can be shown to equal $d^{(j)}_{mm}(2\pi)$ from the definition (3.5.51) and evaluated with (3.9.33). This could be turned into a problem in Chapter Three or Four in the next edition.

Page 297. The statement near the bottom asks a question regarding how one might "visualize $|j, m\rangle$ as being built up of 'primitive' spin $\frac{1}{2}$ objects" but the intent of this statement is not clear to me. I would strike the statement, and focus instead on justifying (4.4.79) through compatibility with rotation formalism, as we do in Problem 10.

Page 300. *Problem 4.1.* Just to be clear, a "box of side L" means a three-dimensional cube.

Page 301. *Problem 4.10.* Again, the time reversal operator should be written $\Theta|\alpha\rangle$, but this problem has too many idiosyncrasies and should be rewritten. (Problems 8 and 9 also have idiosyncrasies, which the interested reader should identify.) For one thing, we are asked to "prove" a phase convention, which is in fact not used by everyone. Furthermore, the problem does not dovetail neatly into the reference to it at the bottom of page 297. Following is a better restatement of Problem 4.10:

(a) Use (4.4.53) to show that $\Theta|jm\rangle$ equals $|j, -m\rangle$ up to some phase that includes the factor $(-1)^m$. That is, show that $\Theta|jm\rangle = e^{i\delta}(-1)^m|j, -m\rangle$, where δ is independent of m.

(b) Using the same phase convention, find the time-reversed state corresponding to $\mathcal{D}(R)|jm\rangle$. Consider using the infinitesimal form $\mathcal{D}(\hat{\mathbf{n}}, d\phi)$ and then generalize to finite rotations.

(c) From these results, prove that, independent of δ, one finds

$$\mathcal{D}^{(j)*}_{m'm}(R) = (-1)^{m-m'}\mathcal{D}^{(j)}_{-m',-m}(R)$$

(d) Conclude that we are free to choose $\delta = 0$, and $\Theta|jm\rangle = (-1)^m|j, -m\rangle = i^{2m}|j, -m\rangle$.

Chapter Five. I remain uncomfortable with the makeup of material in this chapter. Calling it "Approximation Methods" implies that approximations are not introduced elsewhere in the book, but that is not the case. Also, Section 5.5, for example, is not about approximations, and should really be moved to Chapter Two. The most interesting material in this chapter has to do with real-world applications of quantum mechanics. Food for thought.

Pages 306–310. Formal Development of the Perturbation Expansion. I find the flow works better if you start with (5.1.36) (pointing out that $|n\rangle$ will need to be renormalized), then using $\langle n^{(0)}|[H - H_0]|n\rangle = \lambda\langle n^{(0)}|V|n\rangle$ to find expressions for the $\Delta^{(\lambda)}_n$, and then using (5.1.21) to get expressions for the $|n^{(\lambda)}\rangle$, or at least $|n^{(1)}\rangle$.

Page 315. The result $\langle r^2 \rangle = a_0^2$ is incorrect. The line should read $\langle r^2 \rangle = 3a_0^2$ or $\langle z^2 \rangle = a_0^2$.

Page 319. In Equation (5.2.15) the subscript on the sum should be $k \notin D$.

Page 319. Following (5.2.15), after the colon, change "contribution" to "combination."

Page 324. The (very brief) discussion of Thomas precession leads one to the (often given) impression that the result is off "by a factor of two." In fact, the effect of Thomas precession is to subtract one from $g \approx 2$. See "The Thomas precession gives $g_e - 1$ not $g_e/2$", by R. Haar and L. Curtis, Am.J.Phys.55(1987)1044.

Page 327. The treatment of spin-orbit splitting for s-states should be cleaned up. From (5.3.19) it is clear that the shift is zero for $l = 0$. The cancellation of l in numerator and denominator in (5.3.31) is irrelevant for $l = 0$ because (5.3.30) blows up. We get away with using (5.3.31) for $l = 0$, though, because the result is the same as what we get with the Darwin term. This will find its way into the end-of-chapter problems in the next edition.

Page 328. For consistency in notation, (5.3.32) should be written $\mathbf{A} = \frac{1}{2}(\mathbf{B} \times \mathbf{x})$.

Pages 328–330. Why write $|\mathbf{B}|$ instead of just B, as defined in the line following (5.3.33)?

Sections 5.5–5.9. I see a different ordering of the material on time-dependent Hamiltonians. You can derive (5.5.15) from (5.5.4) without reference to the Interaction Picture. Use it solve spin resonance, and then a minor extension to introduce the adiabatic approximation by getting to (5.6.10). This also brings you straight to (5.7.17) and time-dependent perturbation theory. Then do the interaction picture, through to (5.7.6) as a formal development which "can immediately be applied to more advanced problems, such as relativistic quantum field theory and many-body theory."

Page 350. Just before (5.6.28), "curl of a curl" should be "curl of a gradient."

Sections 5.7 & 5.8. The incorporation of the density of states into transition probabilities and cross sections is not done smoothly. This should be rewritten, including better connection to the material in Section 2.5.

Pages 376-385. In the problem statements, it is not necessary to continually quote things like the harmonic oscillator matrix element $\langle n'|x|n \rangle$ and hydrogenic atom wave functions.

Page 376. *Problem 5.1.* Remove the last sentence "You may assume…" and the equation that follows. It is misplaced in the problem statement, uses a notation not from this book for state vectors, and there is no point in the first place as this is all covered in Section 2.3. *Also*, the problem statement would be neater if the λ was removed from the left side of the equation that defines the perturbation.

Page 376. *Problem 5.4.* As discussed above for Problem 5.1, remove the statement in square brackets at the end of part **(c)**.

Page 377. *Problem 5.6.* This is a nice problem, taken directly from Problem 17.7 in Merzbacher (1970), maintaining an open ended style. It should be rewritten in the more explicit manner of this book. For example, $\omega_x = \omega_y \equiv \omega$ and $\omega_z = (1+\epsilon)\omega$ with $\epsilon \ll 1$. (I would also put the magnetic field in the z-direction since it simplifies the angular momentum algebra.) Reference should also be made to Section 3.7, Problem 3.21, and also Problem 2.14.

Page 378. *Problem 5.12.* There is a lot of physics here, relegated to a brief comment on page 319 after "A challenge for the experts." This kind of degeneracy is lifted only by distant states. In future editions, I would like to expand this discussion, but for now, see Problem 1, page 397 of Gottfried (1966), and Section 3.7 (page 155) of Gottfried and Yan (2003).

Page 378. *Problem 5.13.* For consistency with the text, the level labels should use lower case s and p, and the electric field should be $\mathcal{E}$ instead of ε.

Page 379. *Problem 5.16.* I don't know why this problem is in Chapter 5. Perhaps move it to Chapter 3. I would also like to find a reference for the comment about the $q\bar{q}$ potential.

Page 379. *Problem 5.17.* Part **(a)** should also ask for a comparison to the exact solution, as it does in Merzbacher. Furthermore, parts **(a)** and **(b)** should be separate problems; part **(b)** isn't even connected to this chapter. In fact, it is somewhat a rehash of Problem 3.32.

Page 379. *Problem 5.18.* It seems unnecessary to explicitly include the ground state hydrogen wave function or the given definite integral in the problem statement.

Page 380. *Problem 5.19.* This should be part **(b)** of Problem 5.18. In fact, the wave function written with $r_1 + r_2$ is misleading. The perturbation should be treated as independent on each of the two electrons, so simple hydrogen atom wave functions (with the appropriate Z_{eff}) should be used.

Page 380. *Problem 5.20.* It is unnecessary to include the integral.

Page 380. *Problem 5.21.* Some space is needed between "for" and $|x|$ in the first equation. Also, we don't need to include the numerical values given at the end of the problem.

Page 380. *Problem 5.22.* The interpretation is cleaner if the sign is reversed on $V(t)$ so the "forcing function" is $F(t) = +F_0 \cos\omega t$. A comparison to classical physics is also warranted.

Page 382. *Problem 5.28.* There is nothing onerous about the radial integrals. They can be done out. Also, it is worth the work to consider the limit $\tau \to \infty$.

Page 383. *Problem 5.31.* The problem should more properly refer to (5.7.17) and then an analogy to the "second term" in (5.7.36). The point is to fill in the blanks leading up to Section 5.9. This overall discussion could be cleaner.

Page 383. *Problem 5.32.* I don't understand why part **(c)** is not just another question inside part **(a)**.

Page 384. *Problem 5.34.* The question of photon polarization is not clearly answered, so far as I can tell, in the context of the semi-classical treatment of radiation in this and other books on nonrelativistic quantum mechanics. The best discussion I've found is §45 in Schiff (1968). I would like to revisit this problem in the next edition.

Page 384. *Problem 5.37.* The wording is clumsy. The neutron is in a quantum state such that its spin is aligned with a magnetic field "fixed at an angle θ with respect to the **z**-axis, but rotating slowly in the ϕ-direction." Ignore the beginning of the next sentence which talks about "the tip of the magnetic field."

Page 385. *Problem 5.39.* This problem should be moved to Chapter Two, probably as part of Problem 2.27.

Page 385. *Problem 5.41.* There is a lot of physics in this problem that is barely covered in the text, including normalization of the electromagnetic field. The problem should be expanded, or material should be added to the textbook.

Page 386. *Equation (6.1.1).* For consistency, $V(\mathbf{r})$ should be written as $V(\mathbf{x})$.

Page 390. Replace "whose" with "with" in second line from the bottom.

Page 392. I find that students are generally not prepared for contour integration and other important topics in complex analysis. I have prepared some notes on this, and may include them as an appendix in a later edition:
http://www.rpi.edu/dept/phys/Courses/PHYS6520/NotesOnComplexAnalysis.pdf

Page 392. There are some mistakes, starting in (6.2.9) and continuing through to the derivation of (6.2.11). In the second line of (6.2.9), the integration limits on μ are reversed, which contributes to an overall change of sign in the third line. The correct sign is recovered, though, because of a mistake in (6.2.10), linked to misuse of the Residue Theorem. Rewrite the denominator in (6.2.9) as $k'^2 - k^2 \mp i\varepsilon$ to realize the correct usage, and simultaneously fix the sign. For details, see http://www.rpi.edu/dept/phys/Courses/PHYS6520/GreenSigns.pdf

Page 403. Something got lost in translation from the previous edition, which seems to have a much better discussion of the validity of the Born Approximation. Among other things, the equation at the top of the page should have been evaluated in *all* terms at $\mathbf{x} = 0$. This will be fixed in later editions.

Page 404. *Section 6.4* needs to be written. I see some errors whose fixes are not obvious. For example (6.4.21b) appears to have dimensions $[\text{time/length}^3]^{1/2}$, and the second line of (6.4.25) doesn't seem to have taken the integral limit of the sum correctly. These particular problems disappear into a redefinition of $f_l(k)$, but I'd still like to take a more careful look.

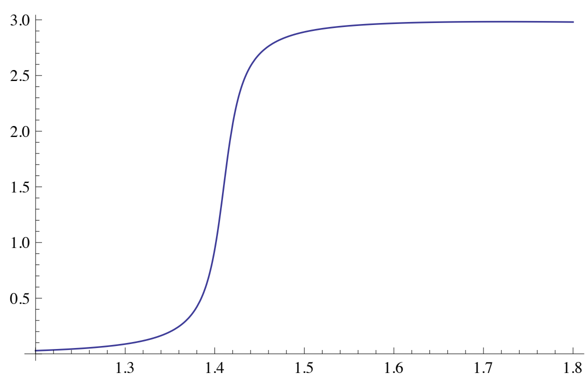
Page 414. Just above (6.4.47), the text should reference Appendix B, not Appendix A.

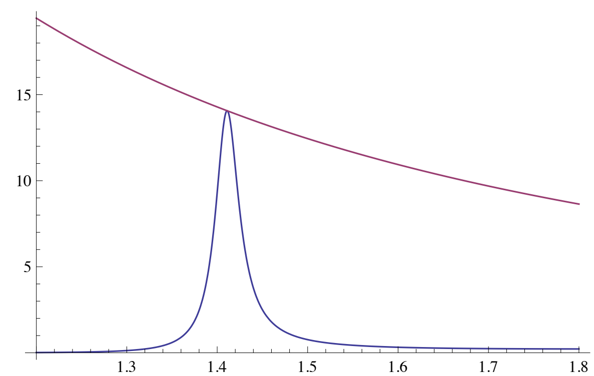
Page 414. *Equation (6.4.50).* The numerator of the first term should be $e^{2i\delta_l}e^{ikr}$.

Page 420. Problem 6.8 actually asks for *both* the Gaussian and Yukawa potentials.

Page 424. *Equation (6.6.5).* A student points out to me that since $j_0(kr) = \sin(kr)/kr$ and $n_0(jr) = -\cos(kr)/kr$, this is a strict equality, not "approximate". This is from the previous edition, however, and the point may have been that we are continuing an approximate approach, namely low energy scattering. So, is this or is this not a typographical error? De gustibus non est disputandum.

Page 432. *Figure 6.15.* I am unable to reproduce this figure with the given parameters, although my code correctly reproduces Figs.13.7 & 13.8 in Merzbacher, 3e. I get somewhat close to Fig. 6.15 using $2mV_0R^2/\hbar^2 = 5.5^2$ (instead of 5.5) but the resonance is much narrower and $k_{\rm res} = 1.41/R$ instead of the value $1.3/R$ given on Page 431 in the text. My results are





Note also that in *Figure 6.15(b)*, the vertical axis should be $\delta_3(k)$, not $\sigma_3(k)$.

Page 432. It would be good to add a figure, and/or perhaps an exercise at the end of the chapter, that shows the data for π^+p elastic scattering and compares it to the unitarity limit, as in Fig.6.15(a). The data is available from the Berkeley Particle Data Group:
http://pdg.lbl.gov/2012/hadronic-xsections/hadron.html

Page 433. *Equation (6.7.6).* The last term should read $\mathcal{O}[(E-E_r)^2]$, that is, on the order of $(E-E_r)^2$, not multiplied by zero.

Page 438. *Equation (6.9.11).* The exponent in the expression to the right of the first "=" should be $i\mathbf{q}\cdot(\mathbf{x}+\mathbf{x}_i)$.

Page 442. *Problem 6.1.* The wording "$E \to E + i\varepsilon$ prescription" is held over from the Revised Edition, and is irrelevant here. You only need the "(+)" solution. For the last part, refer to Problem 2.24. This alludes to some nice physics, which might be worth exploring in the next edition.

Page 443. *Problem 6.6.* This problem should be moved to Chapter 3.

Page 443. *Problem 6.7.* It would seem that this problem was inserted without awareness of what is covered in the textbook, for example the derivation of (6.4.40).

Page 444. *Problem 6.8.* It is useful to know that $\int_1^\infty \exp(-ax)dx/(x^2-1)^{1/2} = K_0(x)$, the modified Bessel function of the second kind, of order zero.

Page 444. *Problem 6.9.* The solution I have found for this problem makes heavy use of the properties of spherical harmonics and Bessel functions. Some, like the "closure relation" for spherical harmonics, may be derived from our quantum mechanics formalism, but others, like the Wronskian for spherical Bessel functions, are more obscure.

Page 445. *Problem 6.13.* The solution to this problem is interestingly connected to the discussion of $SO(4)$ symmetry and the hydrogen atom, starting on page 265. Perhaps this problem should be reworked and moved to Chapter Four. It is not clear to me what it has to do with scattering.

Page 447. *Figure 7.1.* The figure is drawn poorly. The lines external to the "bubble" should be identical for (a) and (b), since the point is that outside the region of overlap, the events cannot be distinguished.

Page 460. In the sentence at the bottom, just above (7.5.10), the word is "multiparticle" not "mutliparticle."

Page 469. *Equation (7.5.52).* The right side should be inverted, that is $(4\pi r_0^3/3)^{-1}$.

Section 7.6. The quantities that multiply the polarization vectors $\hat{\mathbf{e}}_{\mathbf{k},\lambda}$ in (7.6.8) are not vectors so should not be written in bold type. That is, they should be written $A_{\mathbf{k},\lambda}(\mathbf{x},t)$.

Section 7.6. Thanks to Carl Maes at the University of Arizona for pointing me to a very nice article by W. E. Lamb, Appl. Phys. B60(1995)77, title "Anti-Photon." Lamb makes good arguments for why we should stop using the word "photon" which, although are unlikely to win out in the end, are worth reading.

Page 491. In the definition of D_μ just following (8.1.14), where it is first used, I think the sign should be reversed, i.e. $D_\mu \equiv \partial_\mu - ieA_\mu$. The Revised Edition used the unfortunate nomenclature that e was the electron charge, that is, a *negative* number. Most texts with which I am used to, define $e = +4.80325 \times 10^{-10}$ esu, so that the charge on the electron is $-e$. I tried to stick with the definition that e is negative, but I likely missed some places.

Page 502. *Equations (8.3.8).* I don't know why I wrote $U_P^\dagger$ on the right instead of the left.

Clearly it doesn't matter since $U_P = U_P^\dagger$, but to be consistent with the rest of the discussion, it should be similar to the way (8.3.6) is written.

Page 504. Just above (8.3.17) *conjugation* is misspelled.

Page 509. Just above (8.4.19), the second $\psi_1(\mathbf{x})$ should be $\psi_2(\mathbf{x})$.

Page 510. The same wrong sign appears in (8.4.21b) and (8.4.22b). The "$-$" in front of the square brackets for the operator in the second term should be "$+$"; (8.4.26b) is correct.

Page 519. I am much more pleased with a writeup I made subsequently, discussing units in electromagnetism, than I am with this appendix. See
http://www.rpi.edu/dept/phys/Courses/PHYS4210/S10/NotesOnUnits.pdf

Appendix B. All references to equations in Appendix A should be instead to Appendix B.

Page 527. In (B.5.3) replace $R(\tilde{x})$ with $R(r)$.

Page 531. This entry in the Appendix must be modified to connect with (3.7.58) and Problem 3.22. There are different conventions for defining and normalizing the associated Laguerre polynomial. The one used here is directly from Schiff (1968), but differs from, for example, that used in Mathematica. Equations (B.6.7) are correct as written, and can be used to test one's choice of convention.

Page 535. Include an appendix with some Clebsch-Gordan coefficients, for example
http://pdg.lbl.gov/2011/reviews/rpp2011-rev-clebsch-gordan-coefs.pdf

Page 536. *Lectures on Quantum Mechanics*, by Gordon Baym is now published in paperback by Westview Press (1974). The ISBN is 9780805306675.