Introduction

The following errata refer to the hard–cover edition of 2009 and have been already incorporated in the paperback edition published in December 2013.

We are indebted to our colleague Shang–Yung Wang of the Tamkang University, Taiwan for a thorough critical reading of our book, the enlightening correspondence and the very helpful suggestions. His precious work has made these errata possible.

Chapter 1

- In the first line of the second full paragraph in p. 8, change the words "associated to" into "associated with" and do the same across the book.
- Change every occurrence of *Zender* into *Zehnder*. Moreover, in the first paragraph, p. 15, replace the sentence "When T = R = $1/\sqrt{2}$, we have a symmetric (or a 50%–50%) beam splitter" by:

  When T = R = $1/\sqrt{2}$, we have a 50%–50% beam splitter
- In the end of the last paragraph of Sec. 1.2 in p. 20, the phrase "as for example x and px are" is modified into

  as for example the position and the momentum are
- In the first paragraph, Sec. 1.4, p. 28, change $N_t = N_0 e^{-\imath t}$ into $N_t = N_0 e^{-\gamma t}$, *where* $\gamma > 0$ *is the decay constant.*
- Modify Eq. (1.53), p. 29, into
$$\langle a \mid a\rangle = |\langle b \mid a\rangle|^2 + |\langle b_\perp \mid a\rangle|^2 = 1 \; . \tag{1.53}$$
- Replace the first paragraph of Subsec. 1.5.3 (starting with the words "At the beginning of" and ending with the words "in the partition of energy") with:

  At the beginning of the 19$^{\text{th}}$ century it was already experimentally known that the specific heat per mole of monatomic, diatomic, and multiatomic ideal gases is given by $\frac{3}{2}R, \frac{5}{2}R, 3R$, respectively, where $R = N_\text{A} k_\text{B}$ and N_A is the Avogadro number. According to the classical equipartition law, an equilibrium system has an average energy of $k_\text{B}T/2$ for each harmonic degree of freedom (i.e. quadratic term appearing in its Hamiltonian). As a consequence, the specific heat per mole should be equal to $\nu R/2$, where ν is here the number of the degrees of freedom of the molecule. While this correctly explains the experimental value of the specific heat of monoatomic ideal gases, it cannot account for the above experimental values in the case of diatomic and multiatomic ideal gases. This disagreement between the classical equipartition prediction and the experimental value of the molar heat capacity cannot be explained by using a more complex model of the molecule, since adding more degrees of freedom can only increase the predicted specific heat, not decrease it. This discrepancy can be solved by taking into account that energy levels are quantized according to the prediction of quantum mechanics [see Sec. 4.4 on the quantum harmonic oscillator].
- Change Eq. (1.74), p. 37, into
$$E_n = -\frac{2\pi^2 m e^4}{h^2 n^2} \quad (n = 1, 2, 3, \ldots) \; . \tag{1.74}$$
- Change the title of Subsec. 1.5.6 from "Intrinsic magnetic momentum" into

  Intrinsic magnetic moment
- In the first line of the last paragraph, p. 40, change *Schrödinger 's* into *Schrödinger's*.
- Drop Problem 1.10 (and also the solution in the web page).

Chapter 2

- Replace the text of the footnote 6, p. 46, by:

  This is a consequence of a theorem which states that a linear transformation $\hat{O}$, on a Hilbert space, is Hermitian if and only if (iff) $\left\langle \psi \mid \hat{O}\psi \right\rangle$ is real for all vectors $|\psi\rangle$ [*Byorn/Fuller* 1969–70, I, 154].

- Substitute the paragraph after the box, p. 47 (starting with the word "Therefore," and ending with Eq. (2.10)) with the following:

  Moreover, let $\hat{P} = |\varphi\rangle\langle\varphi|$ and consider two arbitrary states $|a\rangle$ and$|b\rangle$. Then,

$$\left\langle a \left| \hat{P}^{\dagger} \right| b \right\rangle = \left\langle b \left| \hat{P} \right| a \right\rangle^{*} = (\langle b \mid \varphi\rangle \langle \varphi \mid a\rangle)^{*} = \langle a \mid \varphi\rangle \langle \varphi \mid b\rangle = \left\langle a \left| \hat{P} \right| b \right\rangle . \tag{2.10}$$

- Change the phrase in the box 2.1 below Eq. (2.8), p. 47 "where $|\varphi\rangle, |\psi\rangle$ are vectors in the Hilbert space such that $\left|\hat{O}\psi\right\rangle$ and $\left|\hat{O}\varphi\right\rangle$ are finite." into

  where $\left|\hat{O}\psi\right\rangle = \hat{O}|\psi\rangle$, $\left\langle\hat{O}\varphi\right|$ is the bra corresponding to $\left|\hat{O}\varphi\right\rangle$, and $|\varphi\rangle, |\psi\rangle$ are vectors in the Hilbert space such that $\left|\hat{O}\varphi\right\rangle$ and $\left|\hat{O}\psi\right\rangle$ are finite.

- In the first line below Eq. (2.53) in p.55, $c_{a_j} = \sum_n U_{j,n} c_{b_j}$ should read

  $c_{a_j} = \sum_n U_{j,n} c_{b_n}$.

- In Eq. (2.55) $\delta_{n,k}$ should read δ_{nk}.
- In the first line below Eq. (2.82) in p. 61, $U_{jk} = o_j^k$ should read $U_{jk} = o_k^j$.
- In Subsec. 2.1.5 and thereafter change *non–commutability* into *non–commutativity.*
- Change the last line of Eq. (2.90), p. 63 into

$$= \begin{bmatrix} 0 & -\sin\phi\cos\phi \\ \sin\phi\cos\phi & 0 \end{bmatrix} \neq 0 . \tag{2.90}$$

- Replace the last equality of Eq. (2.102) by $\sum_n O_{jn} O'_{nk}$.
- Substitute the whole Proof of Corollary 2.1 on p. 67 by the following:

Proof
In fact, if $\hat{O}$ and $\hat{O}'$ commute, then we have a common eigenbasis $\{|o_k, o'_k\rangle\}$ such that

$$\hat{O}\,|o_k, o'_k\rangle = o_k\,|o_k, o'_k\rangle , \tag{2.104a}$$
$$\hat{O}'\,|o_k, o'_k\rangle = o'_k\,|o_k, o'_k\rangle . \tag{2.104b}$$

This means that there is a common basis in which both observables are perfectly determined. In other words, for each state $|o_k, o'_k\rangle$ of the basis, the observable $\hat{O}$, if measured, gives with certainty the eigenvalue o_k as outcome as well as the observable $\hat{O}'$, if measured, gives with certainty the eigenvalue o'_k as outcome.
Q.E.D

- Change Eq. (2.123), p. 71, into

$$\langle x \,|\, \hat{x} = x \,\langle x| \ . \tag{2.123}$$

- Change Eq. (2.127) into:

$$\langle x \,|\hat{x}|\, \psi\rangle \ = x \,\langle x \,|\, \psi\rangle \ , \tag{2.127}$$

- Substitute the whole paragraph on ps. 72-73, starting with words "In classical mechanics" and ending with the words "up to a constant factor" just after Eq. (2.133) by:

In classical mechanics, *momentum* is defined as the quantity which is conserved under global spatial translations or, alternatively, as the generator of spatial translations. Let us then consider a one–dimensional particle described by the wave function $\psi(x)$. A rigid translation by a quantity a of the particle will change $\psi(x)$ into

$$\begin{aligned} \psi(x+a) &= \psi(x) + a\frac{\partial}{\partial x}\psi + \frac{a^2}{2}\frac{\partial^2}{\partial x^2}\psi + \frac{a^3}{6}\frac{\partial^3}{\partial x^3}\psi + \ldots + \frac{a^n}{n!}\frac{\partial^n}{\partial x^n}\psi + \ldots \\ &= \sum_{j=0}^{\infty}\frac{a^j}{j!}\frac{\partial^j}{\partial x^j}\psi(x)) \\ &= \hat{U}_a\psi(x) \ . \end{aligned} \tag{2.130}$$

The unitary operator $\hat{U}_a$ [see Eq. (2.34)], translating the wave function of the system by an amount a, which is called *translation operator*, can be written as

$$\hat{U}_a = e^{\imath a\hat{G}_T} \ . \tag{2.131}$$

As a consequence, the generator $\hat{G}_T$ of the spatial displacements can be identified as

$$\hat{G}_T = -\imath\frac{\partial}{\partial x} \tag{2.132}$$

up to a constant factor and must represent the quantum–mechanical *momentum operator* of the particle (see also Subsec. 3.5.4), i.e.

$$\hat{p}_x = -\imath\frac{\partial}{\partial x} \tag{2.133}$$

up to a constant factor.

- Add the following footnote after the word *into* immediately before Eq. (2.130):

In the one–dimensional case we could use the total derivative instead of the partial one. However, we prefer to use partial derivatives throughout the book.

- Replace $\hat{p}_x$ in the line just before Eq. (2.139), p. 73, by p_x.
- Replace Eq. (2.140), p. 74, by:

$$p_x = \frac{h}{\lambda} = \hbar k_x \ . \tag{2.140}$$

- Change Eq. (2.142) with:

$$\int_{-\infty}^{+\infty} dx|\varphi_p(x)|^2 = \begin{cases} 0 & \text{for} \quad p_x \neq 0 \\ \int_{-\infty}^{+\infty} |C|^2 dx = \infty & \text{for} \quad p_x = 0 \end{cases} . \tag{2.142}$$

- Replace Eq. (2.143) by

$$\int_{-\infty}^{+\infty} dx\varphi_p^*(x)\varphi_{p'}(x) = |C|^2 \int_{-\infty}^{+\infty} dx e^{\frac{\imath}{\hbar}(p_x^{'}-p_x)x} = 2\pi\hbar\,|C|^2\,\delta(p_x^{'}-p_x) \ , \tag{2.143}$$

- In the line below Eq. (2.144) the factor $(2\pi)^{-\frac{1}{2}}$ should be replaced by $(2\pi\hbar)^{-\frac{1}{2}}$. Similarly in Eqs. (2.145), (2.146), (2.150a), (2.150b), (2.163), (2.191), (2.194) and (2.215).
- In Eq. (2.147) the factor $\frac{1}{\sqrt{8\pi^3}}$ should be replaced by

$$\frac{1}{\sqrt{8\hbar^3\pi^3}}$$

- In Eqs. (2.159) and (2.161) replace $d\eta\eta'$ by $d\eta d\eta'$.
- Replace Eq. (2.166) by

$$\hat{H}\,|\,\psi_{_E}\rangle = E\,|\,\psi_{_E}\rangle \ , \tag{2.166}$$

- In the line below Eq. (2.170) replace $k = \sqrt{p^2}/\hbar$ by $k = \sqrt{p_x^2}/\hbar$.
- At the end of Eq. (2.192) add a last line with the equality:

$$= \quad \delta(p_x - p_x') \ .$$

- In the line below E. (2.193) replace $|\psi(x)|^2 = (2\pi)^{-1}$ by $|\psi(x)|^2 = (2\pi\hbar)^{-1}$
- Replace Eq. (2.194) by

$$\tilde{\psi}(p_x) = \tilde{\varphi}_{x_0}(p_x) = \frac{1}{\sqrt{2\pi\hbar}} e^{-\frac{\imath}{\hbar}p_x x_0} \ , \tag{2.194}$$

- In Figs. 2.5 and 2.6, pp. 85–86, $(2\pi)^{-1}\delta(p_x - p_x')$ and $\delta(x - x_0)$ should read $(2\pi\hbar)^{-1}\delta(p_x - p_x')$ and $\delta^2(x - x_0)$. Moreover, the labels of Figs. 2.5(b) and 2.6(b) should read p_x instead of x. Finally, drop the symbol p_x' below Fig. 2.6(b).
- Replace the whole paragraph starting with the words *We assume that* three lines before Eq. (2.201) and ending with Eq. (2.206) with what follows:

We assume that BS1 has (in general, complex) transmission (T) and reflection (R) coefficients that for the sake of simplicity we impose here to be real. These coefficients may be changed, still satisfying the relation $\mathrm{T}^2 + \mathrm{R}^2 = 1$. The BS1 transformation can be described as

$$|\,i\rangle \overset{\mathrm{BS1}}{\mapsto} \mathrm{T}\,|\,1\rangle + \mathrm{R}\,|\,2\rangle \ , \tag{2.201}$$

that is, a quantum superposition of the states "photon in lower path" and "photon in upper path". After the two mirrors and the phase shifter the state becomes

$$\mathrm{T}\,|\,1\rangle + e^{\imath\phi}\mathrm{R}\,|\,2\rangle \ , \tag{2.202}$$

describing the fact that only the upper path acquires a phase factor $e^{\imath\phi}$. The second beam splitter is assumed to be a 50%–50% one. Its action may be described by the transformations

$$|\,1\rangle \overset{\mathrm{BS2}}{\mapsto} \frac{1}{\sqrt{2}}(|\,3\rangle - |\,4\rangle) \ , \quad |\,2\rangle \overset{\mathrm{BS2}}{\mapsto} \frac{1}{\sqrt{2}}(|\,3\rangle + |\,4\rangle) \ , \tag{2.204}$$

so that we can write the outgoing state as

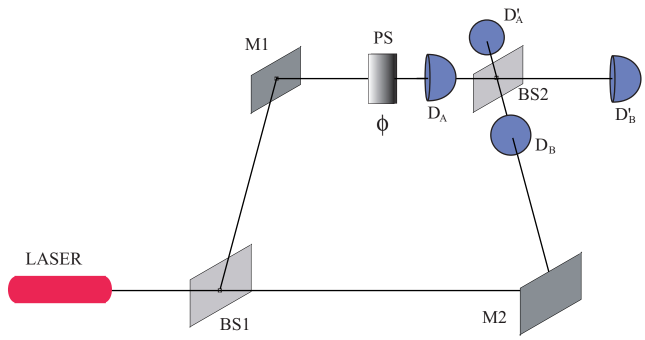
$$\mathrm{T}\,|\,1\rangle + e^{\imath\phi}\mathrm{R}\,|\,2\rangle \overset{\mathrm{BS2}}{\mapsto} \frac{1}{\sqrt{2}}\left[\mathrm{T}\,(|\,3\rangle - |\,4\rangle) + e^{\imath\phi}\mathrm{R}\,(|\,3\rangle + |\,4\rangle)\right] \ .$$

Ordering the terms, the final state is

$$|\,f\rangle = \frac{1}{\sqrt{2}}\left[\left(\mathrm{T} + e^{\imath\phi}\mathrm{R}\right)|\,3\rangle - \left(\mathrm{T} - e^{\imath\phi}\mathrm{R}\right)|\,4\rangle\right] \ . \tag{2.205}$$

It is easy to calculate the final detection probabilities at the two detectors D3 and D4, which are given by the square moduli of the amplitudes of the states $|\,3\rangle$ and $|\,4\rangle$ in the above expression, respectively, i.e.

$$\begin{aligned} \wp_3 &= \frac{1}{2}\left(\mathrm{T} + e^{\imath\phi}\mathrm{R}\right)\left(\mathrm{T} + e^{-\imath\phi}\mathrm{R}\right) = \frac{1}{2} + \mathrm{TR}\cos\phi \ , \\ \wp_4 &= \frac{1}{2}\left(\mathrm{T} - e^{\imath\phi}\mathrm{R}\right)\left(\mathrm{T} - e^{-\imath\phi}\mathrm{R}\right) = \frac{1}{2} - \mathrm{TR}\cos\phi \ . \end{aligned} \tag{2.206}$$



- Substitute Fig. 2.11, p. 94, with the figure above.
- The solution of Problem 2.10 is $3N/16$.
- In Problem 2.17 replace $\int_{-\infty}^{+\infty} dx \left|\tilde{\psi}(p_x)\right|^2 = 1$ by $\int_{-\infty}^{+\infty} dp_x \left|\tilde{\psi}(p_x)\right|^2 = 1$.
- In Problem 2.19 replace Eq. (2.215) by

$$\hat{P}(x)\,|p_x\rangle = \frac{1}{2\pi\hbar} e^{\frac{\imath}{\hbar} p_x x}\,|x\rangle \quad . \tag{2.215}$$

Chapter 3

- Replace Eq. (3.49) by

$$\int_0^a dx|\psi_n(x)|^2 = 1 \ . \tag{3.49}$$

- In the fourth line of item (iii) in p. 110, *which is the energy has to be negative* should read

  that is, for negative values of the energy

- In the fifth line of the first paragraph in p. 111, the sentence beginning with the words *For instance, Galilean relativity* and ending with the words *quantum field theory* should be replaced by:

  For instance, Galilean relativity is the relativity attached to classical mechanics and quantum mechanics, whereas special relativity underlines relativistic quantum mechanics and quantum field theory.

- In the last equality of Eq. (3.57) in p. 116, the pre-factor $\frac{\sqrt{2}}{a}$ should be $\sqrt{\frac{2}{a}}$.

- Replace Eq. (3.68), p. 118, by:

$$\hat{O} \mapsto \hat{O}_{\mathcal{U}} = \sum_j o_j \hat{\mathcal{U}} \,|\, o_j\rangle \langle o_j \,|\, \hat{\mathcal{U}}^\dagger = \hat{\mathcal{U}}\hat{O}\hat{\mathcal{U}}^\dagger \ . \tag{3.68}$$

- Replace the second sentence of Subsec. 3.5.2 ("We wish now to show . . . unitary transformations"), by what follows:

  Generally speaking, the action of a beam splitter can be described by an input–output relation of the type

$$|\,\mathrm{out}\rangle \quad = \quad \hat{U}_{\mathrm{BS}}\,|\,\mathrm{in}\rangle \ ,$$

  where the matrix $\hat{U}$ is given by

$$\hat{U}_{\mathrm{BS}} \quad = \quad \begin{bmatrix} \mathrm{T} & \mathrm{R}' \\ \mathrm{R} & \mathrm{T}' \end{bmatrix} \ ,$$

  T and R being the (in general, complex) transmission and reflection coefficients, respectively. By imposing the requirement of unitarity of the matrix $\hat{U}_{\mathrm{BS}}$, we must have[1]

$$\mathrm{R} = \mathrm{R}'^* \ , \quad \mathrm{T} = -\mathrm{T}'^* \ ,$$

  which implies $|\mathrm{R}| = |\mathrm{R}'|$ and $|\mathrm{T}| = |\mathrm{T}'|$. For the common case of a beam splitter that has the same effect on a beam incident through port 1 as on a beam incident through port 2, that is, a symmetric beam splitter, we have $\mathrm{R} = \mathrm{R}'$ and $\mathrm{T} = \mathrm{T}'$. By imposing this condition together with that of a fifty–fifty beam splitter

[1]See Holbrow, C. H., Galvez, E., and Parks, M. E., "Photon Quantum Mechanics and Beam Splitters", *American Journal of Physics* **70** (2002): 260–65.

($|\mathrm{R}| = |\mathrm{T}|$, which together with the previous one implies $|\mathrm{R}| = |\mathrm{R}'| = |\mathrm{T}| = |\mathrm{T}'|$), it is possible to prove that the unitary matrix above turns into

$$\hat{U}_{\mathrm{BS}} = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & \imath \\ \imath & 1 \end{bmatrix} . \tag{3.72}$$

- Relabel Eqs. (3.72)-(3.73)-(3.74) as (3.73)-(3.74)-(3.75) (shift of one digit) and drop the paragraph starting with the words "For this reason" and ending with Eq. (3.75).

- Replace the line just after Eq. (3.77) together with Problem 3.12 (and its solution) with the following:

  We remark that in the derivation of Subsec. 2.3.4 we have made use of two beam–splitter matrices with real transmission and reflection coefficients, that is, of the matrix

$$\begin{bmatrix} \mathrm{T} & \mathrm{R} \\ \mathrm{R} & -\mathrm{T} \end{bmatrix} ,$$

  for BS1 and of the matrix

$$\frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

  for BS2. These two matrices can derived from the general case by imposing the reality of T and R but cannot account for symmetric beam–splitting. Moreover, the latter describes a 50%–50% beam splitter.

- Replace Eq. (3.90) by

$$\left\langle k \left| e^{-\frac{\imath}{\hbar}\hat{H}(t-t_0)} \right| j \right\rangle = \imath \mathrm{G}(k, t; j, t_0) , \tag{3.90}$$

- Replace Eq. (3.93), p. 123, by

$$\hat{\mathrm{R}}_{\hat{H}}(\eta) = \frac{\imath}{\hbar} \int_0^{+\infty} d\tau e^{-\frac{\eta\tau}{\hbar}} e^{-\frac{\imath}{\hbar}\hat{H}\tau} , \tag{3.93}$$

- In the second line below Eq. (3.95) replace *eta* by η.

- Replace Eq. (3.96) by

$$\hat{P}_j = -\frac{1}{2\pi\imath} \oint_{f_j} d\eta \hat{\mathrm{R}}_{\hat{H}}(\eta) , \tag{3.96}$$

- In the second line after Eq. (3.97) before the words "In the case" insert the following sentence:

  In the continuous case the function $\mathcal{R}$ may have a cut such that the parts above and below it are not analytical continuations one of the other through the cut.

Chapter 4

- Delete the words "are > 0" in the first line of p. 142.
- Replace Eq. (4.7) with

$$\phi = \arctan\frac{k}{k'} \quad \text{and} \quad \phi = -ka - \arctan\frac{k}{k'} + n\pi \ . \tag{4.7}$$

- Replace the phrase "where n is ..." and the following sentence ("In order to address ...") after Eq. (4.7) by the phrase

  where $\arctan(k/k')$ with range in the interval $[-\pi/2, \pi/2]$ is the principal value of the multivalued inverse tangent function and n is an integer

- Substitute the first sentence after Eq. (4.10) with:

  The root $k_0 = 0$ of Eq. (4.8) is excluded because the corresponding eigenfunction vanishes identically for all values of x. The roots k_n with $n \geq 1$ determine the energy eigenvalues $E_n = \hbar^2 k_n^2/2m$.

- no change.
- Replace the words "the parameters $\mathcal{N}_{\mathcal{I}}, \mathcal{N}_{\mathcal{II}}, \mathcal{N}_{\mathcal{III}}$ and ϕ in Eqs. (4.3)" by the words:

  the parameters $\mathcal{N}_{\text{I}}, \mathcal{N}_{\text{II}}$, and $\mathcal{N}_{\text{III}}$ in Eqs. (4.3)

- Replace Eq. (4.14), p. 144, by:

$$\psi'(x) - \psi'(b) = \int_b^x dx' \psi''(x') \ . \tag{4.14}$$

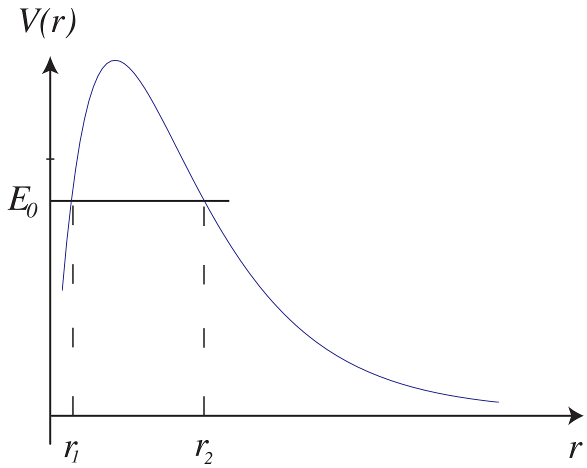
- Substitute any $\mathbf{V}$ and $d\mathbf{V}$ in Sec. 4.2 by V and dV, respectively.
- Replace k_{21} in Eq. (4.31) by k_1. Moreover, substitute k_1 in the line after Eq. (4.31) by k_2.
- After Eq. (4.38) insert the sentence:

  In order to find the first derivative of the wave function across the point $x = 0$, we take advantage of

$$\psi_{\text{II}}^{'}(0) - \psi_{\text{I}}^{'}(0) = \lim_{\epsilon \to 0^+} \int_{-\epsilon}^{\epsilon} dx \psi^{''}(x) \ .$$

- Substitute Fig. 4.9c by the figure in the next page.
- Change the label of Eq. (4.55a) into (4.55).
- In the final inequality in Eq. (4.63) change the symbol $\geq$ into $>$.
- The second line of Eq. (4.72) should be replaced by:

$$= \quad \frac{1}{2} m \left(\omega^2 x_{n,n+1}^2 + \omega^2 x_{n,n-1}^2 + \omega^2 x_{n,n+1}^2 + \omega^2 x_{n,n-1}^2 \right)$$



(c)

- In the line immediately below Eq. (4.61), p. 156, substitute the sentence "Eq. (4.61) teaches us that the energy levels of a harmonic oscillator are equally spaced (see Fig. 4.11)" by the words:

  Eq. (4.61), together with the fact that the energy levels of a one-dimensional harmonic oscillator are not degenerate, teaches us that the energy levels E_n are equally spaced (see Fig. 4.11)

- In the following sentence, the phrase "for any value of $j > 0$" must be deleted.

- The sentence immediately below Eq. (4.67), p. 157, "ω is an antisymmetric matrix since" should be modified to:

  ω_{nm} is antisymmetric on its two indices since

- Replace Eqs. (4.73), p. 158, by:

$$\hat{a} = \sqrt{\frac{m}{2\hbar\omega}}\left(\omega\hat{x} + \imath\frac{\hat{p}_x}{m}\right) , \tag{4.73a}$$
$$\hat{a}^\dagger = \sqrt{\frac{m}{2\hbar\omega}}\left(\omega\hat{x} - \imath\frac{\hat{p}_x}{m}\right) , \tag{4.73b}$$

- Eq. (4.78) must be modified into:

$$\begin{aligned} \hat{a}^\dagger\hat{a} &= \frac{m}{2\hbar\omega}\left(\omega\hat{x} - \imath\,\frac{\hat{p}_x}{m}\right)\left(\omega\hat{x} + \imath\,\frac{\hat{p}_x}{m}\right) \\ &= \frac{m}{2\hbar\omega}\left(\omega^2\hat{x}^2 + \frac{\imath\omega}{m}\hat{x}\hat{p}_x - \frac{\imath\omega}{m}\hat{p}_x\hat{x} + \frac{\hat{p}_x^2}{m^2}\right) \\ &= \frac{m}{2\hbar\omega}\left(\omega^2\hat{x}^2 + \frac{\imath\omega}{m}\left[\hat{x},\hat{p}_x\right] + \frac{\hat{p}_x^2}{m^2}\right) \\ &= \frac{1}{\hbar\omega}\left(\frac{1}{2}m\omega^2\hat{x}^2 + \frac{\hat{p}_x^2}{2m}\right) - \frac{1}{2} , \end{aligned} \tag{4.78}$$

- Substitute $\dot{\hat{x}}$ in Prob. 4.10 into $\hat{p}_x$.

- Replace Eq. (4.97) by:

$$\psi_n(\xi) = \frac{\pi^{-\frac{1}{4}}e^{-\frac{\xi^2}{2}}}{2^{\frac{n}{2}}\sqrt{n!}}\mathrm{H}_n(\xi) , \tag{4.97}$$

- The text of Prob. 4.14 should be changed into

  Verify that the ground–state wave function of the harmonic oscillator is normalized.

- Drop the solution of Prob. 4.14.

- Replace Eq. (4.112) by

$$V(x) = -Fx + C \ . \tag{4.112}$$

- Replace Eq. (4.114) by

$$\zeta(x) = \left(x + \frac{E}{F}\right)\left(\frac{2m|F|}{\hbar^2}\right)^{\frac{1}{3}} \ , \tag{4.114}$$

- Replace Eq. (4.115) by

$$\psi''(\zeta) + \mathrm{sgn}(F)\zeta\psi(\zeta) = 0 \ , \tag{4.115}$$

- Replace Eq. (4.119) by

$$\zeta(x) = \left(x + \frac{E'}{F}\right)\left(\frac{2m|F|}{\hbar^2}\right)^{\frac{1}{3}} \ . \tag{4.119}$$

- Replace Eq. (4.121) by

$$\zeta = \left(x + \frac{E_n}{F}\right)\left(\frac{2m|F|}{\hbar^2}\right)^{\frac{1}{3}} \tag{4.121}$$

- Replace Eq. (4.122) by

$$\psi''(\zeta) - \zeta\psi(\zeta) = 0 \ , \tag{4.122}$$

- Replace Eq. (4.123) by

$$\psi(\zeta) = \mathcal{N}\mathrm{A}(\zeta) \tag{4.123}$$

- In the line just after Eq. (4.123) replace N by $\mathcal{N}$.
- After the words "Lorentz force" just before Eq. (4.127) insert the following footnote:

  Here and throughout this book we make use of the SI system of units.

- Eq. (4.127), p. 168, must be substituted by

$$\frac{d\mathbf{p}}{dt} = \mathrm{e}\left(\mathbf{E} + \frac{\mathbf{p}}{m} \times \mathbf{B}\right) \ , \tag{4.127}$$

- Eq. (4.129), p. 168, must be substituted by

$$\mathrm{L} = \frac{1}{2}m\dot{r}^2 + \mathrm{e}\left(\dot{\mathbf{r}} \cdot \mathbf{A} - \mathrm{U}\right) \ . \tag{4.129}$$

- Eq. (4.130) on page 168 should read:

$$H = \sum_j \dot{q}_j \frac{\partial \mathrm{L}}{\partial \dot{q}_j} - \mathrm{L} = \dot{\mathbf{r}} \cdot \frac{\partial \mathrm{L}}{\partial \dot{\mathbf{r}}} - \mathrm{L} \ , \tag{4.130}$$

- Eq. (4.131) on page 168 should read:

$$\begin{aligned} H &= \frac{\mathbf{p}}{m} \cdot (\mathbf{p} + \mathrm{e}\mathbf{A}) - \tfrac{\mathbf{p}^2}{2m} - \frac{\mathrm{e}}{m}\mathbf{p} \cdot \mathbf{A} + \mathrm{eU} \\ &= \frac{1}{2m}\mathbf{p}^2 + \mathrm{eU} \\ &= \frac{1}{2m}\left(\mathbf{P} - \mathrm{e}\mathbf{A}\right)^2 + \mathrm{eU} \ , \end{aligned} \tag{4.131}$$

- Eq. (4.132), p. 169, must be substituted by

$$\mathbf{P} = \frac{\partial \mathrm{L}}{\partial \dot{\mathbf{r}}} = \mathbf{p} + \mathrm{e}\mathbf{A} \tag{4.132}$$

- After Eq. (4.132), p. 169, the words "we replace the generalized momentum by the operator $\hat{\mathbf{p}} = -\imath\hbar\boldsymbol{\nabla}$, so that" must be replaced by the words:

  we impose the canonical commutation relation $[\hat{r}_j, \hat{P}_k] = \imath\hbar\delta_{jk}$ (see Eq. (2.174)) and replace the generalized momentum $\hat{\mathbf{P}}$ by the operator $-\imath\hbar\boldsymbol{\nabla}$, so that

- Drop the footnote 11, p. 169.
- Eq. (4.133), p. 169, must be replaced by

$$\hat{H} = \frac{1}{2m}\left(-\imath\hbar\boldsymbol{\nabla} - \mathrm{e}\mathbf{A}\right)^2 + \mathrm{eU}\ . \tag{4.133}$$

- Eq. (4.134), p. 169, must be replaced by

$$\imath\hbar\frac{\partial}{\partial t}\psi(\mathbf{r},t) = \frac{1}{2m}\left[-\imath\hbar\boldsymbol{\nabla} - \mathrm{e}\mathbf{A}(\mathbf{r},t)\right]^2\psi(\mathbf{r},t) + \mathrm{eU}(\mathbf{r},t)\psi(\mathbf{r},t)\ , \tag{4.134}$$

- Eq. (4.135), p. 169, must be replaced by

$$\begin{aligned}\imath\hbar\frac{\partial}{\partial t}\psi(\mathbf{r},t) &= \left[\frac{\hat{\mathbf{P}}^2}{2m} - \frac{\mathrm{e}}{2m}\left(\hat{\mathbf{P}}\cdot\mathbf{A} + \mathbf{A}\cdot\hat{\mathbf{P}}\right) + \frac{\mathrm{e}^2}{2m}\mathbf{A}^2 + \mathrm{eU}\right]\psi(\mathbf{r},t) \\ &= \left[-\frac{\hbar^2}{2m}\Delta + \frac{\mathrm{e}\imath\hbar}{2m}\boldsymbol{\nabla}\cdot\mathbf{A} + \frac{\mathrm{e}\imath\hbar}{m}\mathbf{A}\cdot\boldsymbol{\nabla} + \frac{\mathrm{e}^2}{2m}\mathbf{A}^2 + \mathrm{eU}\right]\psi(\mathbf{r},t)\ .\end{aligned} \tag{4.135}$$

- The last sentence of Sec. 4.5.3 and the following Eq. (4.136), p. 169 must be replaced by:

  In the last expression we have taken into account the fact that $\hat{\mathbf{P}}$ and $\mathbf{A}$ do not commute, and their (scalar) commutator is given by (see Prob. 2.26)

$$\left[\hat{\mathbf{P}}, \mathbf{A}\right]_. = \hat{\mathbf{P}}\cdot\mathbf{A} - \mathbf{A}\cdot\hat{\mathbf{P}} = -\imath\hbar\boldsymbol{\nabla}\cdot\mathbf{A}\ . \tag{4.136}$$

- In Prob. 4.5 substitute the exponential $e^{\imath\frac{E_n t}{\hbar}}$ with $e^{-\imath\frac{E_n t}{\hbar}}$.
- In Prob. 4.7 change the phrase "in any of the energy eigenstates" into "in any energy eigenstate".
- In Prob. 4.8, change the phrase "the eigenstates of the discrete spectrum" into "the energy eigenstate $|n\rangle$ of the discrete spectrum".
- Change Prob. 4.13 into

  Prove the relation $|n\rangle = \frac{\left(\hat{a}^\dagger\right)^n}{\sqrt{n!}}|0\rangle$, where $|n\rangle$ is the energy eigenstate of the harmonic oscillator with energy eigenvalue $E_n = (n + 1/2)\hbar\omega$.

Chapter 5

- In the first line after Eq. (5.20), p. 178, replace the word "where" by "and if".
- In Eq. (5.32b) substitute on the left side the term $S_{\rm VN}$ with S.
- In the second line of p. 182 replace the words "the direct sum $\mathcal{H}_1 \oplus \mathcal{H}_2$" by the words:

  the direct product $\mathcal{H}_1 \otimes \mathcal{H}_2$
- In the third line from the bottom of p. 186 change the expression $\mathcal{H}_{\mathcal{S}+\mathcal{S}'} = \mathcal{H}_{\mathcal{S}} \oplus \mathcal{H}_{\mathcal{S}'}$ into $\mathcal{H}_{\mathcal{S}+\mathcal{S}'} = \mathcal{H}_{\mathcal{S}} \otimes \mathcal{H}_{\mathcal{S}'}$.
- Replace the sentence containing Eq. (5.35), p. 182 (starting with the words "A complete basis for the total system of the two photons will then be given by the direct product" and ending with the words "each basis element of $\mathcal{H}_2$") by:

  A complete basis of the direct product Hilbert space $\mathcal{H}_1 \otimes \mathcal{H}_2$ for the total system of the two photons will then be given by the direct product basis

  $$\{|h\rangle_1 \otimes |h\rangle_2, |h\rangle_1 \otimes |v\rangle_2, |v\rangle_1 \otimes |h\rangle_2, |v\rangle_1 \otimes |v\rangle_2\} , \tag{5.35}$$

  which is obtained by performing the direct product of each basis vector of $\mathcal{H}_1$ and each basis vector of $\mathcal{H}_2$.
- After Eq. (5.40), p. 183, insert the words:

  In Eq. (5.40) and in the following repeated indices are dropped.
- Just after Eq. (5.43) insert the words:

  For the sake of notational simplicity, the direct product sign $\otimes$ will be omitted here and henceforth except where confusion may arise.
- Replace the last line of Eq. (5.46), p. 184, by:

  $$= \sum_{j,l,n} c_{jn} c_{ln}^* |j\rangle\langle l| , \tag{5.46}$$

Chapter 6

- Eq. (6.1), p. 193 must be replaced by

$$\mathbf{L} = \mathbf{r} \times \mathbf{p} \ , \tag{6.1}$$

- Replace the words “where $\hat{R} = \mathbf{n} \cdot \hat{\mathbf{l}}$ is called the *generator of the rotation*.” after Eq. (6.10) on p. 196, with the words:

  where $\hat{R} = \mathbf{n} \cdot \hat{\mathbf{l}}$ is called the *generator of the rotation* about the direction given by the vector $\mathbf{n}$.

- Replace $\hat{R}^2$ with $\hat{R}$ in the third line after Eq. (6.12) on page 197.

- Transform the text of footnote 1 from “See [*Byron/Fuller* 1969–70, 11].” to

  We follow for the Euler angles the $z - y - z$–convention [*Byron/Fuller* 1969–70, 11].

- In the first line of Subsec. 6.1.4, p. 200, substitute the words “angular momentum operator.[4]” with

  angular momentum operator[4].

- In the third line of Subsec. 6.1.4, substitute the words “only half–integer values of l are suitable” with the words

  only integer or half–integer values of l are suitable

- Substitute the words “generates the rotations about z” in the first line after Eq. (6.34), p. 201, with the words

  generates the rotations about the z axis

- Replace Eq. (6.48), p. 203 with

$$\hat{\mathbf{l}}^2 \left| 0, 0 \right\rangle = 0 \ . \tag{6.48}$$

- P. 206, second line after Eq. (6.70), replace the words “around x–and y–axes” with the words

  around x– and y–axes

- Replace Eq. (6.71) with what follows:

$$\frac{xy}{r^2} \ , \ \frac{yz}{r^2} \ , \ \frac{zx}{r^2} \ , \ \frac{3z^2 - r^2}{r^2} \ , \ \frac{x^2 - y^2}{r^2} \ , \tag{6.71}$$

  corresponding to $d_{xy}, d_{yz}, d_{xz}, d_{z^2}$, and $d_{x^2-y^2}$, respectively.

- Replace Eq. (6.88), p. 210, with

$$\hat{p}_r = -\imath\hbar \frac{1}{r} \frac{\partial}{\partial r} r = -\imath\hbar \left(\frac{\partial}{\partial r} + \frac{1}{r} \right) \ , \tag{6.88}$$

- Replace Eq. (6.98), p. 211, with

$$\lim_{r\to 0} r^2 V(r) = 0 \ , \tag{6.98}$$

- Replace Eq. (6.102), p. 212, with

$$\mathbf{A} = -\frac{B}{2}\hat{y}\boldsymbol{\imath} + \frac{B}{2}\hat{x}\boldsymbol{\jmath} + 0\boldsymbol{k} \ , \tag{6.102}$$

- Eq. (6.103), p. 212, must be replaced by

$$\begin{aligned} \hat{H} &= \frac{1}{2m}\left[\left(\hat{p}_x + \frac{\mathrm{e}B}{2}\hat{y}\right)\boldsymbol{\imath} + \left(\hat{p}_y - \frac{\mathrm{e}B}{2}\hat{x}\right)\boldsymbol{\jmath} + \hat{p}_z\boldsymbol{k}\right]^2 \\ &= \frac{\hat{p}_z^2}{2m} + \frac{1}{2m}\left(\hat{p}_x^2 + \hat{p}_y^2\right) - \frac{\mathrm{e}\hbar B}{2m}\hat{l}_z + \frac{\mathrm{e}^2 B^2}{8m}\left(\hat{x}^2 + \hat{y}^2\right) \ . \end{aligned} \tag{6.103}$$

- Eq. (6.104), p. 212 must be replaced by

$$\hat{H}_r = \frac{1}{2m}\left(\hat{p}_x^2 + \hat{p}_y^2\right) - \frac{\mathrm{e}\hbar B}{2m}\hat{l}_z + \frac{\mathrm{e}^2 B^2}{8m}\left(\hat{x}^2 + \hat{y}^2\right) \ , \tag{6.104}$$

- Eq. (6.110), p. 213, must be replaced by

$$(2n+1)\frac{\mathrm{e}\hbar B}{2m} \tag{6.110}$$

- Eq. (6.111) must be replaced by

$$E_n = \frac{\hbar^2 k_z^2}{2m} + (2n+1)\frac{\mathrm{e}\hbar B}{2m} \ . \tag{6.111}$$

- Substitute e^{-kr^2} with $e^{-\omega r^2/2\hbar}$ in the first line after Eq. (6.131) as well as in Eq. (6.132), p. 217.
- Replace Eq. (6.136), p. 219, with

$$\mu_p \simeq \frac{1}{1000}\mu_e \ , \tag{6.136}$$

- Replace Eq. (6.143), p. 220, with

$$\psi(\mathbf{r}, s) = \begin{pmatrix} \psi_\uparrow(\mathbf{r}) \\ \psi_\downarrow(\mathbf{r}) \end{pmatrix} = \psi_\uparrow(\mathbf{r})\begin{pmatrix} 1 \\ 0 \end{pmatrix} + \psi_\downarrow(\mathbf{r})\begin{pmatrix} 0 \\ 1 \end{pmatrix} \ . \tag{6.143}$$

  Replace Eq. (6.146), p. 221 with

$$\psi(\mathbf{r}, s) = \langle \mathbf{r} \mid \psi\rangle = \langle \mathbf{r} \mid \psi_\uparrow\rangle \left|\uparrow\right\rangle_z + \langle \mathbf{r} \mid \psi_\downarrow\rangle \left|\downarrow\right\rangle_z \ . \tag{6.146}$$

- Replace Eq. (6.148), p. 221 with

$$\hat{s}_z = \frac{1}{2}\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \ . \tag{6.148}$$

- Replace the expressions “electric dipole momentum”, “magnetic dipole momentum” and “magnetic momentum” used in Sec. 6.3 (and in the caption of Fig. 6.10) by “electric dipole moment”, “magnetic dipole moment” and “magnetic moment”, respectively.
- In the line immediately below Eq. (6.160), replace the phrase “and, if $\hat{O}$ is real, also α and $\boldsymbol{\beta}$ must be real” by

  and $\hat{O}$ is Hermitian if and only if α and $\boldsymbol{\beta}$ are real
- In the sentence just before Eq. (6.161) replace the reference “(see Eq. (6.145))” by “(see Eqs. (6.143) and (6.145))”.
- After Eq. (6.162) add the words:

  where the transmission and reflection coefficients T and R (see Subsecs. 2.3.4 and 3.5.2) are absorbed into the amplitudes ψ_1 and ψ_2.

- Replace Eqs. (6.165) by

$$\hat{s}_x = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} , \quad \hat{s}_y = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & -\imath & 0 \\ \imath & 0 & -\imath \\ 0 & \imath & 0 \end{bmatrix} , \quad \hat{s}_z = \frac{1}{\sqrt{2}} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix} . \tag{6.165}$$

- Eq. (6.166), p. 224, must be replaced by

$$\hat{\boldsymbol{\mu}}_l = \frac{e\hbar}{2m} \hat{\mathbf{l}} \tag{6.166}$$

- Eq. (6.167), p. 224, must be replaced by

$$\mu_B = \frac{e\hbar}{2m} \tag{6.167}$$

- Eq. (6.169), p. 225, must be replaced by

$$\hat{\boldsymbol{\mu}}_s = g \frac{e\hbar}{2m} \hat{\mathbf{s}} \tag{6.169}$$

- Eq. (6.172), p. 225, must be replaced by

$$\hat{H} = \frac{1}{2m} \left(\hat{p}_x + eBy \right)^2 + \frac{\hat{p}_y^2}{2m} + \frac{\hat{p}_z^2}{2m} - \tilde{\mu} \hat{s}_z B , \tag{6.172}$$

- Eq. (6.173), p. 225, must be replaced by

$$\tilde{\mu} = g \frac{e\hbar}{2m} . \tag{6.173}$$

- Eq. (6.174), p. 226, must be replaced by

$$\left[\frac{1}{2m} \left(\hat{p}_x + eBy \right)^2 + \frac{\hat{p}_y^2}{2m} + \frac{\hat{p}_z^2}{2m} - \tilde{\mu} s_z B \right] \psi(\mathbf{r}) = E \psi(\mathbf{r}) . \tag{6.174}$$

- Eqs. (6.177), p. 226, must be replaced by

$$\omega_{B} = \frac{eB}{m} \quad \text{and} \quad y_0 = -\frac{p_x}{eB} . \tag{6.177}$$

-

- P. 228, Eq. (6.182): replace all occurrences of $\hat{\mathbf{l}}_{1,2}$ by $\hat{\mathbf{l}}$ as well as of $\hat{l}_{1,2}$ by $\hat{l}$. Do the same in the whole subsection (for instance the whole paragraph after Eq. (6.184).

- Replace Eqs. (6.191) by:

$$\hat{J}_x = \frac{\hbar}{\sqrt{2}} \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix} , \quad \hat{J}_y = \frac{\hbar}{\sqrt{2}} \begin{bmatrix} 0 & -\imath & 0 \\ \imath & 0 & -\imath \\ 0 & \imath & 0 \end{bmatrix} , \quad \hat{J}_z = \hbar \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & -1 \end{bmatrix} , \quad \hat{\mathbf{J}}^2 = 2\hbar^2 \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} . \tag{6.191}$$

- In Subsec. 6.4.1 all the occurrences of $\hat{\mathbf{l}}_{1,2}$ should be replaced by $\hat{\mathbf{l}}$ as well as all the occurrences of $\hat{l}_{1,2}$ should be replaced by $\hat{l}$.

- Replace $|+1,-1\rangle_1 |2,-1\rangle_2$ in caption of Fig. 6.13 by $|1,-1\rangle_1 |2,-1\rangle_2$.

- Insert a right parenthesis at the end of the second line of Prob. 6.10, p. 242.

- Replace Eq. of Prob. 6.25, p. 243 by:

$$(\hat{\boldsymbol{\sigma}} \cdot \mathbf{f}) (\hat{\boldsymbol{\sigma}} \cdot \mathbf{f}') = (\mathbf{f} \cdot \mathbf{f}') \hat{I} + \imath \hat{\boldsymbol{\sigma}} \cdot (\mathbf{f} \times \mathbf{f}') ,$$

Chapter 7

- In the caption of Tab. 7.1, p. 250, replace the expressions "the particle τ" and "τ particles" by "the τ lepton" and "τ leptons", respectively.
- Replace the expression E_{n_1} E_{n_2} in the second line of p. 251 by:

  E_{n_1} and E_{n_2}
- Replace the expression "where $\xi_{l_1}, \xi_{l_2}, \ldots, \xi_{lN}$" in the line immediately below Eq. (7.17), p. 251, by:

  where $\xi_{l_1}, \xi_{l_2}, \ldots, \xi_{l_N}$
- Replace the formula $k!/(k-n)!$ in the fifth line below Principle 7.2, p. 251, by:

  $k!/(k-N)!$
- Replace the term "disposition" in the 5th, 7th and 8th lines below Principle 7.2 and in Footnote 11, p. 251, by the term "permutation".
- Replace Eq (7.21), p. 253, by:

$$\psi(\xi_1, \xi_2, \ldots, \xi_N) = \psi(\xi_{l_1}, \xi_{l_2}, \ldots, \xi_{l_N}) \ , \tag{7.21}$$

- Replace Eq. (7.24), p. 254, by:

$$Y_{lm}(\theta, \phi) \to Y_{lm}(\pi - \theta, \phi + \pi) = (-1)^l Y_{lm}(\theta, \phi) \ . \tag{7.24}$$

- Replace Eq. (7.26), p. 255, by:

$$\lambda_T = \sqrt{\frac{h^2}{2\pi m k_{\mathrm{B}} T}} \ , \tag{7.26}$$

- In the 8th line of Subsec. 7.5.2, replace formula $V(\mathbf{r}) \sim 1/\mathbf{r}$ by

  $V(\mathbf{r}) \sim 1/|\mathbf{r}|$

Chapter 8

- Replace Eq. (8.4), p. 260, by

$$\begin{aligned} |\psi\rangle \quad &\mapsto \quad \hat{U}_{\mathrm{BS}}\,|\psi\rangle = \left|\psi^{'}\right\rangle \\ &= \quad \frac{1}{\sqrt{2}}\left(|1\rangle + |2\rangle\right) \ . \end{aligned} \tag{8.4}$$

- Replace Ee. (8.5), p. 261, by:

$$\left|1^{'}\right\rangle = \frac{1}{\sqrt{2}}\left(|1\rangle - |2\rangle\right) \ , \qquad \left|2^{'}\right\rangle = \frac{1}{\sqrt{2}}\left(|1\rangle + |2\rangle\right) \ . \tag{8.5}$$

- In the line immediately below Eq. (8.20), p. 264, "for an arbitrary eigenstate ketx" should read

  for an arbitrary eigenstate $|x\rangle$

- Replace Eq. (8.22), p. 264, by:

$$\hat{U}_x(a)\hat{x}\hat{U}_x^{\dagger}(a) = \hat{x} - a \ , \tag{8.22}$$

- Replace Eq. (8.27), p. 265, by

$$\hat{U}_{\mathbf{p}}(\mathbf{v}) = e^{\frac{i}{\hbar}\mathbf{v}\cdot\hat{\mathbf{r}}} \tag{8.27a}$$

  or

$$\hat{U}_{\mathbf{p}}(\mathbf{v})\hat{\mathbf{p}}\hat{U}_{\mathbf{p}}^{\dagger}(\mathbf{v}) = \hat{\mathbf{p}} - \mathbf{v} \ . \tag{8.27a}$$

- Replace Eq. (8.30), p. 266, by:

$$\hat{U}_{\mathbf{R}}(\phi) = e^{-\frac{i}{\hbar}\phi\mathbf{n}\cdot\hat{\mathbf{J}}} \ , \tag{8.1}$$

- Change the title of Subsec. 8.3.1 from "Space reflection" into "Space reflection or parity".
- In the last line of the last paragraph of Subsec. 8.3.1, p. 267, the sentence "time reversal operator commutes with the generator of rotations." should be replace by

  time reversal operator anticommutes with the generator of rotations.

- Replace the sentence "A noticeable example of isomorphism is provided by the groups C. and D. of the previous section" by

  A noticeable example of isomorphism is provided by the groups 3. and 4. of the previous subsection

- Replace the words "check the correctness if this statement" immediately above Eq. (8.39), p. 269, by:

  check the correctness of this statement

- Replace Eq. (8.43), p. 270, by:

$$\sum_{b=1}^{3} R_{ab}^{\mathrm{T}} R_{bc} = \delta_{ac}. \tag{8.43}$$

- Replace Eq. (8.44), p. 270, by

$$(R * t)_{abc} = \sum_{d,e,f=1}^{3} R_{ad} R_{be} R_{cf} t_{def} \ . \tag{8.44}$$

- Replace Eq. (8.45), p. 270, by:

$$\sum_{a=1}^{3} t_{aab} = \sum_{a=1}^{3} t_{aba} = \sum_{a=1}^{3} t_{baa} = 0 \ . \tag{8.45}$$

- Replace Eq. (8.48), p. 271, by:

$$r * (t + v) = \sum_{b=1}^{d} r_{ab}(t_b + v_b) \ . \tag{8.48}$$

- Replace Eq. (8.52), p. 273, by:

$$\sum_{a',b'=1}^{d} R^{\mathrm{T}}_{aa'} g_{a'b'} R_{b'b} = g_{ab} \, , \tag{8.52}$$

  which for $g_{ab} = \delta_{ab}$ and $d = 3$ reduces to Eq. (8.43).

- Replace Eq. (8.53), p. 273, by:

$$g_{ab} = \delta_{ab} f_a \ , \tag{8.53}$$

  Replace the sentence "This group is usually called $O(d_1, d_2)$, where $d_1 + d_2 = 1$." by:

  > This group is called the indefinite orthogonal group $O(d_1, d_2)$, where $d_1 + d_2 = d$.

- In the second last line of the third last paragraph in p. 273, $g(0) = 1$ should be replaced by $g(\mathbf{0}) = 1$.

- Replace Eq. (8.55), p. 274, by:

$$m = \sum_{i=1}^{3} R_i v_i \ , \tag{8.55}$$

- Eq. (8.56), p. 274, should be replaced by:

$$[T_i, T_k] = \sum_{l} C_{ikl} T_l \ , \tag{8.56}$$

- Replace Eq. (8.57), p. 274, by:

$$C * r = Ar \ , \tag{8.57}$$

- Replace Eq. (8.58), p. 274, by:

$$C = \hat{l}_x^2 + \hat{l}_y^2 + \hat{l}_z^2 \tag{8.58}$$

- Replace the displayed equation in Problem 8.1, p. 275, by:

$$|1\rangle = \frac{1}{\sqrt{2}} \left(\left| 1' \right\rangle + \left| 2' \right\rangle \right) \ ,$$

- In Further Reading, p. 276, replace "Eisberg, R./Resnick, R." by "Eisberg, R. and Resnick, R.".

Chapter 9

- The sentence immediately above Eq. (9.9) ("In general, there will be a unitary operator describing the evolution during the interaction time τ, i.e. ") should be replaced by:

  If the interaction Hamiltonian dominates during the interaction time τ over the free terms of the Hamiltonian, the unitary operator describing the evolution during the interaction time may be written as

- Three lines above Eq. (9.26), p. 284, replace $\hat{U}_{\mathcal{SA}}$ by $\hat{U}_{\tau}^{\mathcal{SA}}$.
- In the line immediately below Eq. (9.42c), p. 298, replace $\{|e_j\}$ by $\{|\, e_j\rangle\,\}$.
- Replace the text of Footnote 49, p. 311, by:

  See Box 13.1: p. 494.

- In the line immediately below Eq. (9.81), p. 313, replace $|1_1 0_2\rangle\ |0_1 1_2\rangle$ by $|1_1 0_2\rangle$, $|0_1 1_2\rangle$.
- In the third line from the end of the first paragraph, p. 315, "photosensory" should be replaced by "photosensor".
- Drop the Phase shifter PS in Fig. 9.12, p. 316.
- Eq. (9.91), p. 316, should be replaced by:

$$
\begin{aligned}
|i\rangle \ &\overset{\text{BS1}}{\mapsto} \ \frac{1}{\sqrt{2}}\left(|1\rangle + |2\rangle\right) \overset{\text{M1,M2}}{\mapsto} \frac{1}{\sqrt{2}}\left(|1\rangle + |2\rangle\right) \\
&\overset{\text{BS2}}{\mapsto} \ \frac{1}{2}\left(|3\rangle - |4\rangle\right) + \frac{1}{2}\left(|3\rangle + |4\rangle\right) = |3\rangle \ ,
\end{aligned}
\tag{9.91}
$$

- Drop the words "As usual, upon reflection the state vector acquires an imaginary factor." three lines after Eq. (9.91).
- Replace Eq. (9.92), p. 316, by:

$$
\begin{aligned}
|i\rangle \ &\overset{\text{BS1}}{\mapsto} \ \frac{1}{\sqrt{2}}\left(|1\rangle + |2\rangle\right) \overset{\text{O}}{\mapsto} \frac{1}{\sqrt{2}}\left(|1\rangle + |a\rangle\right) \\
&\overset{\text{M1,M2}}{\mapsto} \ \frac{1}{\sqrt{2}}\left(|1\rangle + |a\rangle\right) \overset{\text{BS2}}{\mapsto} \frac{1}{2}\left(|3\rangle - |4\rangle\right) + \frac{1}{\sqrt{2}}|a\rangle \ ,
\end{aligned}
\tag{9.92}
$$

- Replace the formula in Footnote 66, p. 324, by:

$$
\lim_{n\to\infty}\left(1 + \frac{x}{n}\right)^n = e^x
$$

- In the line immediately below Eq. (9.104), p. 325, replace $\parallel \langle o|\Psi_{\mathcal{SS}'}(\tau)\rangle \parallel = \wp(o)$ by $\parallel \langle o|\Psi_{\mathcal{SS}'}(\tau)\rangle \parallel^2 = \wp(o)$.
- In the line immediately below Eq. (9.112), p. 328, substitute $= \text{Sup}\,\{\text{Tr}\,[\mathcal{T}(\hat{\rho})]\}$ with

  $\parallel \mathcal{T} \parallel = \text{Sup}\,\{\text{Tr}\,[\mathcal{T}(\hat{\rho})]\}$

- Replace "Elzevier" by "Elsevier" in the second item of QND measurement, p. 354.

Chapter 10

Chapter 11

- Eq. (11.22), p. 407, must be replaced by

$$\mu_B = \frac{\mathrm{e}\hbar}{2m} \,. \tag{11.22}$$

- In Figure 11.4, p. 412, the $\tilde{r}$ axis is misplaced. It should be moved down so that it become the asymptote of the solid line.

- Eq. (11.57), p. 415, must be replaced by

$$\mathbf{B}_p = \mathbf{E} \times \mathbf{v} = \frac{Z\mathrm{e}}{r^3}\mathbf{r} \times \mathbf{v} = \frac{Z\mathrm{e}}{m_e}\frac{1}{r^3}\mathbf{L} = B_p \boldsymbol{k} \,, \tag{11.57}$$

- Eq. (11.58), p. 415, must be replaced by

$$\boldsymbol{\mu}_s = \frac{1}{2}\frac{\mathrm{e}}{m_e}\mathbf{S} \,, \tag{11.58}$$

- Eq. (11.59), p. 415, must be replaced by

$$V = -\boldsymbol{\mu}_s \cdot \mathbf{B}_p = \frac{Z\mathrm{e}^2}{2m_e^2 r^3}\mathbf{L} \cdot \mathbf{S} = \frac{1}{2}\frac{Zc\alpha\hbar}{m_e^2}\frac{\mathbf{L} \cdot \mathbf{S}}{r^3} \,, \tag{11.59}$$

- Eq. (11.63), p. 415, must be substituted by

$$\left\langle \varphi_{nlm}^{(0)} \left| V \right| \varphi_{nlm}^{(0)} \right\rangle = \frac{Z\mathrm{e}^2}{2m_e^2} \left\langle \hat{\mathbf{L}} \cdot \hat{\mathbf{S}} \right\rangle_{\text{ang,spin}} \left\langle \frac{1}{r^3} \right\rangle_{\text{rad}} \,, \tag{11.63}$$

- Eq. (11.65), p. 415, must be replaced by

$$E_{nlm}^{(1)} = \frac{Z^4 c\alpha\mathrm{e}^6}{2\hbar^5 n^3 l \left(l + \frac{1}{2}\right)(l+1)} \left\langle \hat{\mathbf{L}} \cdot \hat{\mathbf{S}} \right\rangle_{\text{ang,spin}} = \kappa \left\langle \hat{\mathbf{l}} \cdot \hat{\mathbf{s}} \right\rangle_{\text{ang,spin}} \,, \tag{11.65}$$

- Eq. (11.66), p. 416, must be replaced by

$$\kappa = \frac{Z^4 c\alpha\mathrm{e}^6 m_e}{2\hbar^3 n^3 l \left(l + \frac{1}{2}\right)(l+1)} = \frac{Z^4 \alpha^4 m_e c^4}{2n^3 l \left(l + \frac{1}{2}\right)(l+1)} \,, \tag{11.66}$$

- Eq. (11.68), p. 416, must be replaced by

$$\hat{H} = \hat{H}_A - \frac{\mathrm{e}\hbar}{2m_e}\left(\hat{\mathbf{l}} + 2\hat{\mathbf{s}}\right) \cdot \mathbf{B}_{\text{ext}} - f(r)\,\hat{\mathbf{l}} \cdot \hat{\mathbf{s}} \,, \tag{11.68}$$

- Eq. (11.69), p. 416, must be replaced by

$$f(r) = \frac{Z\mathrm{e}^2\hbar^2}{2m_e^2 r^3} \,. \tag{11.69}$$

- Eq. (11.71), p. 417, must be replaced by

$$\hat{H} = \hat{H}_A - \frac{e\hbar}{2m_e} B_{\text{ext}} \left(\hat{l}_z + 2\hat{s_z} \right) - f(r)\, \hat{\mathbf{l}} \cdot \hat{\mathbf{s}} = \hat{H}_0 + \hat{H}_I \ , \tag{11.71}$$

- Eq. (11.72) must be replaced by

$$\hat{H}_0 = \hat{H}_A - \frac{e\hbar}{2m_e} B_{\text{ext}} \left(\hat{l}_z + 2\hat{s}_z \right) \ , \tag{11.72}$$

- Eq. (11.75), p. 417, must be replaced by

$$\begin{aligned} \hat{H}_0 \varphi_{nlm_l m_s} &= \left[\hat{H}_A - \frac{e\hbar}{2m_e} B_{\text{ext}} \left(\hat{l}_z + 2\hat{s_z} \right) \right] \varphi_{nlm_l m_s} \\ &= \left[E_{nl}^{(0)} - \mu_B B_{\text{ext}} \left(m_l + 2m_s \right) \right] \varphi_{nlm_l m_s} \ , \end{aligned} \tag{11.75}$$

- Eq. (11.80), p. 420, must be replaced by

$$\hat{H}_I = -\frac{e\hbar}{2m_e} B_{\text{ext}} \left(\hat{l}_z + 2\hat{s_z} \right) \ . \tag{11.80}$$

- Eq. (11.82), p. 421, must be replaced by

$$\mu_j = \mu_l \cos\theta + \mu_s \cos\phi = \frac{e\hbar}{2m_e} \left(l \cos\theta + 2s \cos\phi \right) \ , \tag{11.82}$$

- Eq. (11.86), p. 421, must be replaced by

$$\mu_j = \frac{e\hbar}{2m_e} \left(\frac{j^2 + l^2 - s^2}{2j} + 2\frac{j^2 + s^2 - l^2}{2j} \right) = \frac{e\hbar}{2m_e} g_L j \ , \tag{11.86}$$

- Replace the words "Gauss, law" in the immediately immediately above Eq. (11.97), p. 424, by:

  the Gauss law

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At the end of Footnote 2 add the words:

> The only difference with formulation (5.33) is that here we have taken the Boltzmann constant $k_{\mathrm{B}} = 1$. The reason is that we deal here with pure informational aspects and not with thermodynamical or statistic–mechanics considerations.