

Atom Optics — Erratum

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The following misprints have been brought to my attention. I would very much appreciate your help in identifying further mistakes. Please communicate them to me at pierre.meystre@optics.arizona.edu.

Particular thanks are due to the Japanese translators of the book (to be published by Springer-Verlag Tokyo), Prof. Atsuo Morinaga and Dr. Kazuhito Honda, Faculty of Science and Technology, Tokyo University of Science, who have identified a number of misprints. They must be credited for all corrections whose author is not named explicitly.

Chapter 1 — Light Forces on Atoms

The text in the line following Eq. (1.15) should read “... and the atomic transition frequency ω_0 ...”.

(*Found by Adil Gangat*)

Eq. (1.21) should read:

$$\rho_{eg} \rightarrow \tilde{\rho}_{eg} e^{-i\omega t}.$$

In Eqs. (1.32)-(1.33), $\hbar\Omega(\mathbf{r})$ should read $\Omega(\mathbf{r})$.

(*Found by Henning Christ*)

Page 11, Eqs. (1.32) and (1.34), there should be an i in front of the time derivatives on the LHS, and $\hbar\Omega(\mathbf{r})$ should be $\Omega(\mathbf{r})$.

Page 13, Eq. (1.44) should read:

$$\mathcal{F}(\mathbf{r}_0) = \frac{\hbar}{2} \rho_{ge, \text{st}} \nabla \left(\Omega(\mathbf{r}) e^{-i\Phi(\mathbf{r})} e^{-i\omega t} + c.c. \right)_{\mathbf{r}=\mathbf{r}_0}$$

Page 18, 3 lines before Eq. (1.60), the text should read “ $\hbar\mathbf{k}$ is the momentum ...”

Page 20, Eq. (1.68) should read

$$\dot{\rho} = -\frac{i}{\hbar} \left[H_{\text{eff}} \rho - \rho H_{\text{eff}}^\dagger \right] + \Gamma \sigma_- \rho \sigma_+.$$

Chapter 2 — Atomic cooling

Page 25, RHS of Eq. (2.4), only the \mathbf{r} 's should be bold-face.

Page 30, Eq. (2.27) should read

$$\Lambda_{\text{dB}} \equiv \frac{2\pi\hbar}{\sqrt{2\pi M k_B T}}.$$

Also, two lines below Eq. (2.28), “ $\hat{\epsilon}_x$ and $\hat{\epsilon}_x$...” should read “ $\hat{\epsilon}_x$ and $\hat{\epsilon}_y$...”.

Page 32, the Clebsch-Gordan coefficients in the figure should have a square root.

Eq. (2.38) should read

$$s_0 = \frac{1}{4} \left(\frac{\Omega^2}{\delta^2 + (\Gamma/2)^2} \right),$$

and Eq. (2.40) should read

$$V_{\text{opt}} = \hbar\delta s_0 \Lambda^\dagger(z) \Lambda(z).$$

Page 33, horizontal axis of Fig. 2.3. The right-most σ should be a σ_- .

Page 34, 7 lines after Eq. (2.45), the text should read “... decay to the ground state $|g_{+1/2}\rangle$.”

Chapter 3 — Collimation and Focusing

Page 36, second line, should be $\hbar\Omega^2/|\delta|$.

Page 36, 4 lines before Eq. (2.52), add “circular” between the words “orthogonal” and “polarizations.”

Page 40, 2 lines after Eq. (2.66): g -actor should be g -factor.

Page 46, following Eq. (3.1), should read $v_0 \simeq 0$.

Page 47, 9-th line, $T \simeq \hbar$ *Gamma* should be $k_B T \simeq \hbar\Gamma/2$. Also, Eqs. (3.5) and (3.6) should read respectively

$$\Delta v_{\perp}(\rho) = \frac{F_{\perp}(\rho)t_{\text{int}}}{M}$$

and

$$\Delta\phi(\rho) = \frac{\Delta v_{\perp}(\rho)}{v_z} = \frac{F_{\perp}(\rho)L}{Mv_z^2}.$$

Page 48, Eqs. (3.10) and (3.11) should read respectively

$$U_{\text{opt}}(\rho, z) = -\hbar\delta\rho^2/\rho_0^2$$

and

$$\mathcal{F}_{\rho} = \frac{\partial U}{\partial \rho} = 2\hbar\delta\rho/\rho_0^2.$$

Also page 48, Eq. (3.13) should read

$$\begin{aligned} U_{\text{opt}} &\simeq \frac{\hbar\delta}{4} \left(\frac{\Omega^2}{\delta^2 + (\Gamma/2)^2} \right) \\ &\simeq \Omega_0^2 \left(\frac{\hbar\delta/4}{\delta^2 + (\Gamma/2)^2} \right) \left(\frac{w_0^2}{w^4(z)} \right) \rho^2 + O(\rho^4). \end{aligned}$$

Page 52, Eq. (3.26) should read

$$\kappa = \left(\frac{\lambda}{2\pi} \right) \frac{1}{\sqrt{n^2 \sin^2 \vartheta_i - 1}}.$$

Page 53, Eq. (3.31) should read

$$\mathcal{F}_{\text{react},z} = \frac{\hbar\delta}{2\kappa} \left[\frac{\Omega^2(z)}{\delta^2 + (\Gamma/2)^2} \right].$$

Page 55, Eq. (3.37) should read

$$\Omega^2(\mathbf{r}) = \Omega_0^2 \left(\frac{w_x}{w_x(z)} \right) \left(\frac{w_y}{w_y(z)} \right) \exp \left[-2 \left(x^2/w_x(z)^2 + y^2/w_y(z)^2 \right) \right].$$

Chapter 4 — Atomic diffraction

Page 59, Eq. (4.2) should read

$$f(t) = \Theta(t) - \Theta(t - L/v_x).$$

Page 60, third line following Eq. (4.5), the text should read “initial condition should read $|\psi(0)\rangle = g(p=0, t=0)|g\rangle$.” Also, Eq. 4.8) should have $(-i)^m$ rather than i^m .

Page 61, 5 lines from the top, should read $\hbar m^2 \omega_{\text{rec}}$.

Page 61, 8 lines from the bottom, should read $t \ll 1/\sqrt{8\Omega_0\omega_{\text{rec}}}$.

Page 62, Eq. (4.11) should read:

$$i\hbar \frac{\partial g(z, t)}{\partial t} = -\frac{\hbar^2}{2M} \frac{\partial^2 g(z, t)}{\partial z^2} + \frac{\hbar\Omega_0^2}{\delta} \cos^2(kz)g(z, t).$$

Page 63, the label on the horizontal axis of the figure should be $-m$.

Page 64, Eq. (4.18) should read

$$\begin{aligned} E_1(z) &= -\hbar\Omega_0 \cos(kz), \\ E_1(z) &= \hbar\Omega_0 \cos(kz). \end{aligned}$$

Page 65, 2 lines below Eq. (4.20), should read “occurring at the nodes ...”.

Page 66, the master equation should of course be the same as in Eq. (1.65), that is it should read

$$(\dot{\rho})_{\text{sp}} \equiv \mathcal{L}_D \rho = \frac{\Gamma}{2}(\sigma_+ \sigma_- \rho + \rho \sigma_+ \sigma_-) + \Gamma \int d^2 \mathbf{n} \Phi(\mathbf{n}) e^{-ik\mathbf{n}\cdot\mathbf{r}} \sigma_- \rho \sigma_+ e^{ik\mathbf{n}\cdot\mathbf{r}}.$$

Page 70, Eq. (4.31), $U(\mathbf{r})$ should read $\mathcal{U}(\mathbf{r})$.

Chapter 5 — Atomic traps and cavities

Page 77, first line after Eq. (5.10), should be “gyromagnetic ratio.” Also, in Eq. (5.13), there is a $d^3 r$ missing in the integrand on the left-hand-side. Also, page 78, there is a square bracket too many on the right of Eqs. (5.18) and (5.18).

Eqs. (5.21) and (5.22) are off by dreaded factors of 2, and should read

$$\begin{aligned} B &\simeq B_0 + \frac{B'^2}{4B_0} (x^2 + y^2 + 8z^2) \\ &= B_0 + B''_\rho \rho^2 + B''_z z^2, \end{aligned}$$

and

$$\frac{B'^2}{4B_0} = B''_\rho = \frac{B''_z}{8},$$

respectively. Consequently, Eq. (5.23) should read

$$U = \mu_m [B_0 + B''_\rho \rho^2 + B''_z z^2].$$

To see in some more detail how this works, we start from the magnetic field of a TOP-trap, which is given from Eqs. (5.18) and (5.20) by

$$\mathbf{B}_{\text{TOP}} = \mathbf{B} + \mathbf{B}_{\text{bias}} = \begin{pmatrix} B'x + B_0 \cos \omega t \\ B'y + B_0 \sin \omega t \\ -2B'z \end{pmatrix}, \quad (1)$$

with modulus

$$B_{\text{TOP}} = B_0 \sqrt{1 + \frac{B'^2}{B_0^2} (x^2 + y^2 + 4z^2) + \frac{2B'}{B_0} (x \cos \omega t + y \sin \omega t)}. \quad (2)$$

For B_0 much larger than the other terms, we expand the square root to second order to find

$$\begin{aligned} B_{\text{TOP}} &\simeq B_0 + \frac{B'^2}{2B_0} (x^2 + y^2 + 4z^2) + B' (x \cos \omega t + y \sin \omega t) \\ &\quad - \frac{B_0}{8} \left[\frac{B'^4}{B_0^4} (x^2 + y^2 + 4z^2)^2 + \frac{4B'^3}{B_0^3} (x^2 + y^2 + 4z^2) (x \cos \omega t + y \sin \omega t) \right] \\ &\quad - \frac{B'^2}{2B_0} (x \cos \omega t + y \sin \omega t)^2. \end{aligned}$$

For small distances from the center of the trap, $x, y, z \ll |B_0/B'|$, we neglect the second line of this equation and carry out the time averaging over a period of the field, with

$$\begin{aligned}\frac{\omega}{2\pi} \int_0^{2\pi/\omega} dt (x \cos \omega t + y \sin \omega t) &= 0, \\ \frac{\omega}{2\pi} \int_0^{2\pi/\omega} dt (x \cos \omega t + y \sin \omega t)^2 &= \frac{1}{2} (x^2 + y^2).\end{aligned}$$

This gives finally, after eliminating the subscript ‘‘TOP’’ for notational simplicity,

$$\begin{aligned}B &\simeq B_0 + \frac{B'^2}{4B_0} (x^2 + y^2 + 8z^2) \\ &= B_0 + B''_\rho \rho^2 + B''_z z^2,\end{aligned}$$

where $\rho^2 = x^2 + y^2$ and

$$\frac{B'^2}{4B_0} = B''_\rho = \frac{B''_z}{8}.$$

(Found by I. G. Hughes and M. Leadbeater)

Page 79, Fig. 5.3, the current in the lower coil should be in the same direction as in the upper coil.
Page 81, Eq. (5.28) should read

$$U \simeq \mu \left[B_0 + \frac{B''_\rho}{2} \rho^2 + \frac{B''_z}{2} z^2 \right].$$

Page 87, second line after Eq. (5.42), the text should read ‘‘Ai(ζ)’’.
Also page 87, Eqs. (5.43) and (5.44) should read respectively

$$\psi_n(z) = \text{Ai} \left[\left(\frac{2M^2g}{\hbar^2} \right)^{1/3} \left(z - \frac{E_n}{Mg} \right) \right]$$

and

$$\psi_n(0) = \text{Ai} \left[- \left(\frac{2M^2g}{\hbar^2} \right)^{1/3} \frac{E_n}{Mg} \right] = 0.$$

Chapter 6 — Collisions

Equation (6.12) should read:

$$\mathcal{H}_f = \frac{\epsilon_0}{2} \int d^3r \left[\frac{\hat{\mathbf{D}}^2(\mathbf{r})}{\epsilon_0^2} + c^2 \hat{\mathbf{B}}^2(\mathbf{r}) \right].$$

(Found by Iwo Bialynicki-Birula)

Page 100, the argument of the delta function in Eq. (6.17) should not be bold-faced.

Page 104, last of the Eqs. (6.32), Δ_n should read Δ_μ . Also, in Eqs. (6.36) and (6.39), all δ -functions should read $\delta(c|k| - \omega_a)$ and $\delta(c|k| - \omega_0)$, respectively. and Eq. (6.40) should read:

$$\Gamma_2(x) = \Gamma \int_0^\infty d\omega \frac{\omega}{\omega_0} \delta(\omega - \omega_0) \cos\left(\frac{\omega x}{c}\right) = \Gamma \cos(k_0 x).$$

(Found by Han Pu)

Page 115, Eq. (6.92) should read

$$\psi_{\text{ex}}(r)|_{k \rightarrow 0} \rightarrow \left(1 - \frac{a}{r} \right).$$

Chapter 7 — Simple applications

Page 121: all references to Eq. (7.12) should be to Eq. (7.11). Also, Eq. (7.14) should read

$$(-1)^{j+k} \frac{1}{2\ell} \cos(\pi k_{\nu'} z/2\ell) [1 - |z|/\ell] \Theta(\ell = |z|).$$

Page 128, Eq. (7.34) should read

$$U_{mn}(\mathbf{r}) = \frac{2\pi\hbar^2 a}{\mu} \varphi_m^*(\mathbf{r}) \varphi_n(\mathbf{r}).$$

Also, $\phi_n(\mathbf{r})$ should read $\varphi_n(\mathbf{r})$ in the following line and in Eq. (8.24).

Chapter 8 — Manybody theory

Page 142, first line should read “annihilation operators are to the left of the creation operators,...”

Page 147, in the definition (8.52) of the healing length, there should be a factor 2 at the denominator.

Chapter 9 — Matter-wave coherence

In the line following Eq. (9.7), the word “screen” should be replaced by “slit.”

In Eq. (9.15), there should be a \hbar in front of the integral, and a_ℓ should read a_μ . Also, In Eq. (9.16), there is a subscript missing the polarization vector of the laser, which should be ϵ_L .

Page 163, there is a right square bracket too many at the end of the fourth line and a right curly bracket too many at the end of the sixth line.

Chapter 10 — Bose-Einstein condensation

Page 166, the “hats” on top of the operators \hat{c}_j^\dagger and \hat{c}_j are missing in Eq. (10.1).

Page 167, two lines after Eq. (10.15), the text should read “...Eq. (10.13) is obtained by intersecting ... with the left-hand side of this equation.”

Page 178, last line of text, replace “equation (10.4)” by “equation (10.46)”.

(*Found by Kunal Das*)

Page 183, first line after the figure, the text should read “equation (10.46)...”

Page 185, Eq. (10.92), there is a right parenthesis missing in $|\phi(\mathbf{r})|^2$.

Page 186, Eq. (10.95), there is a right parenthesis missing in $|v_j(\mathbf{r})|^2$.

Chapter 11 — Atom lasers

Page 199, this is Figure 11.3, not Figure 1.3. Same for the text directly following the figure. Likewise, two lines before the end of the section, this should be “Figure 11.4.” The numbering of the following section should be “11.2.2” instead of “1.2.2”.

Page 200: The figure should be labelled Figure 11.4, and the equation quoted (twice) in the text is Eq. (11.7) and not Eq. (1.7).

Page 209, Eq. (11.41): Replace k_{opt} by k_L in the argument of the cosine function.

There are several misprints in page (212):

The last equality in Eq. (11.51) should read

$$\chi_c = \left| \frac{d_2 \hbar \delta'}{g} \right|.$$

In the second line of Eq. (11.52), $|\psi|^2$ should be replaced by $(|\phi_1|^2 + |\phi_{-1}|^2)$.

The last column vector on the first line of Eq. (11.55) should have φ_{-1} instead of ϕ_{-1} .

Finally, the third line after Eq. (11.55) should read “becomes $\pm 1 = \text{sgn}(g)$ ”.

Page 213, last line, the dispersion relation should read $\omega(\kappa) = \mu\kappa^2 + \mu k_L^2 \pm \sqrt{i + \kappa^2}$. (Note that the inclusion of the constant term μk_L^2 does not change any of the physics.)

Page 216: replace q by η in the figure caption.

Chapter 12 — Nonlinear wave mixing

In equation (12.1), first line, the Kronecker δ 's should read δ_{ja} and δ_{jb} instead of δ_{ia} and δ_{ib} .

(Found by Kunal Das)

Page 222, second line of Eq. (12.3), it should be ρ_b instead of ρ_a .

Page 224, Eq. (12.14) should be

$$[\hat{b}_\mu(\mathbf{k}), \hat{b}_\nu^\dagger(\mathbf{k}')] = \delta_{\mu\nu} \delta(\mathbf{k} - \mathbf{k}').$$

Same page, last line of Eq. (12.18), replace $\phi_a^* \phi_b^*$ by $\sqrt{\rho_a \rho_b}$.

Page 225, Eq. (12.23) should read

$$|\psi_\pm\rangle = \frac{1}{\sqrt{2}}(|\psi_a\rangle \pm |\psi_b\rangle).$$

Page 226, 12 lines above Eq. (12.29), replace $p \rightarrow 0$ by $k \rightarrow 0$. Also, Eq. (12.29) should read

$$\hbar\omega_\pm(k) = \left\{ \frac{\hbar^2 k^2}{2M} \left[\left(\frac{\hbar^2 k^2}{2M} + \hbar V_s \rho \right) \pm \hbar^2 [V_s^2 (\rho_a - \rho_b)^2 + 4V_x^2 \rho_a \rho_b]^{1/2} \right] \right\}^{1/2}.$$

Page 227, at the end of the caption, add “($p = \hbar k$.)”

Page 229, first line of Eq. (12.41), the “+” sign just left of the closing parenthesis should be removed. Also, four lines from the bottom of the page, this should be $\mathcal{P}_0 + \mathcal{P}_2 = \hat{I}$.

Page 232, at the end of the caption of Fig. 12.2, add the sentence: “Here, $c = \hbar c_2 n/2$.”

Page 234, caption of Fig. 12.3: the antiferromagnetic case is $c_2 > 0$ and the ferromagnetic case is $c_2 < 0$. same page, 5 lines from bottom, replace n by N .

Page 237, the line following Eq. (12.71) should read “are automatically satisfied if either $i = j = m = n$ or $i = m \neq j = n$.”

Page 242 has several misprints:

Eq. (12.82) should read

$$\hat{D} = a_1^\dagger a_1 - a_{-1}^\dagger a_{-1}.$$

Equation (12.85) should read

$$\mathbf{a}_1 \equiv \begin{pmatrix} a_{01} \\ a_1 \end{pmatrix} \quad \text{and} \quad \mathbf{a}_2 \equiv \begin{pmatrix} a_{-1} \\ a_{02} \end{pmatrix}.$$

Equation (12.87) should read

$$\mathbf{S}_2 \equiv \mathbf{a}_2^\dagger \sigma \mathbf{a}_2 = \frac{1}{2} \begin{pmatrix} a_{-1}^\dagger a_{02} + a_{02}^\dagger a_{-1} \\ \frac{1}{i}(a_{02} a_{-1}^\dagger - a_{02}^\dagger a_{-1}) \\ a_{-1}^\dagger a_{-1} - a_{02}^\dagger a_{02} \end{pmatrix}.$$

Page 241, 3 lines from bottom: “Eq. (12.79)” should be “Eq. (12.78)”.

Page 243, Eq. (12.90) should read

$$\mathcal{H} = \frac{\hbar^2 k_0^2}{2M} \hat{N} + \frac{\hbar c_0}{2V} \hat{N}(\hat{N} - 1) + \frac{2\hbar c_2}{V} \left[\mathbf{S}^2 - \frac{\hat{N}}{2} - \left(\frac{\hat{D}_0}{2} \right)^2 \right].$$

Chapter 13 — Mixing of optical and matter waves

Page 252, fifth line, replace “twice” by “half.” Also, there is a $g_{\mathbf{k}\lambda}$ factor missing in the sum (see Eq. (13.2)).

Pages 253 and 255, replace Δ by δ in Eqs. (13.5), (13.13), and (13.14).