ERRATA TO "QUANTUM FIELD THEORY"

(first printing)

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The following errata were corrected in the second printing. Additional errata found since these corrections were made (in August 2013) are in a separate document.

"line $-n$" means "line n from the bottom."

Page 5, line −2: one newton $\rightarrow$ 2×10^{-7} newton

Page 8, 7 lines above (1.7): atoms about $\rightarrow$ atoms are about

Page 10, 4 lines above (1.11): $y + \mathbf{p}|^2$ $\rightarrow$ $y + |\mathbf{p}|^2$

Page 15, line 9: $w = 0$ $\rightarrow$ $v = 0$

Page 15: In the next-to-last display, $X_{\{f,g\}}h$ should be $-X_{\{f,g\}}h$, so the correspondence $f \mapsto X_f$ is an antihomomorphism. To fix this, change the definition of X_f (two displays earlier) to $\Omega(Y, X_f) = Yf$.

Page 16, line 25: $\mathbf{x}_n$ $\rightarrow$ $\mathbf{x}_k$

Page 17, line 11: $\mathbf{x}_n$ $\rightarrow$ $\mathbf{x}_k$

Page 17, line −8: $\arctan(p/x)$ $\rightarrow$ $\arctan(\widetilde{p}/\widetilde{x})$

Page 18, line −9: ∇V $\rightarrow$ $-\nabla V$

Page 21, next-to-last display: m $\rightarrow$ μ

Page 23, line 1: to realize $\rightarrow$ was

Page 24, line −1: $-\,mc^2$ $\rightarrow$ $+\,mc^2$

Page 25, line before (2.18): §1.1 $\rightarrow$ §1.2

Page 27, formula (2.24): $\mathbf{j}$ $\rightarrow$ $\mathbf{j}/c$

Page 28, line after (2.27): (2.25) $\rightarrow$ (2.26)

Page 28, display after (2.28): $\mathbf{j}$ $\rightarrow$ $\mathbf{j}/c$

Page 33, line 5: Delete "with".

Page 39, line −11: $\lambda(xy)/\lambda(x)\lambda(y)$ $\rightarrow$ $\lambda(x)\lambda(y)/\lambda(xy)$

Page 40, line 2: bilinear $\rightarrow$ skew-symmetric bilinear

Page 40, end of 4th paragraph, "This is the quantum version of Noether's theorem": Not quite. The quantum version of Noether's theorem is that if a one-parameter group of symmetries commutes with the Hamiltonian, then the observable that generates it commutes with time translations.

Page 41, line 16: $ic[A_1, A_2]$ $\rightarrow$ $ib[A_1, A_2]$

Page 41, line 18: $[A_1, A_2]$ $\rightarrow$ $ib[A_1, A_2]$

Page 45. formula 3.13: $e^{v\cdot w/i\hbar}$ $\rightarrow$ $e^{-v\cdot w/i\hbar}$

Page 45, line −2: The t's on this line are a parameter, not the last coordinate on the Heisenberg group. You might want to replace them with s's to avoid confusion.

Page 47, line 5: mometum → momentum

Page 50, lines −18 and −17: $\mathbf{x}_m \to \mathbf{x}_N$

Page 53, display after (3.21) and the following line: $\sqrt{m\kappa} \to \sqrt{m/\kappa}$

Page 54, 5th display: $\langle AA^\dagger \phi_l | \phi_k \rangle \to \langle \phi_{l-1} | AA^\dagger \phi_{k-1} \rangle$

Page 57, line −13: infintesimal → infinitesimal

Page 58, line 15: $\kappa \to \kappa'$

Page 58, 3rd display: $e^{i(m-k)} \to e^{i(m-k)t}$

Page 60, line 2 of Section 3.6: Insert minus sign before $\dfrac{h^2}{2m}\nabla^2$

Page 67, 3rd line after 2nd display: $j^0 \to \rho$ and $\rho \to \int \rho$

Page 68, formula (4.6): $x_j \to x^j$

Page 71, line 8: The last L^ν_ρ should be L^ν_σ.

Page 73, 3rd line after (4.26): $\gamma^m \to \gamma^\mu$

Page 73, line −3 and page 74, line 1: $A_\mu + \partial_\mu \chi \to A_\mu - \partial_\mu \chi$

Page 75, line −9: $mc^2\|\psi\| \to mc\|\psi\|$

Page 76, line 2: $\dfrac{e}{2m} \to e$ and $\dfrac{e}{m} \to 2e$

Page 76, display before (4.32): $e^2 \to \frac{1}{4}e^2$

Page 76, formula (4.32): $\dfrac{e^2}{2m} \to \dfrac{e^2}{8m}$

Page 80, third displayed formula: Both exponents 1/2 should be −1/2.

Page 82, line 18: a photon → a pair of photons [to satisfy conservation of momentum]

Page 85, line 3: bundle B → bundle B over G/H

Page 85, line 5: at g → at $\overline{g}$

Page 87, line −6: $\kappa(A) \to \kappa(A)^{-1}$

Page 90, formula (4.45): $\dfrac{n_1!n_2!\cdots}{k!} \to \dfrac{k!}{n_1!n_2!\cdots}$

Page 91, line −5: $\mathcal{F}^o_s \to \mathcal{F}^0_s$

Page 91, line −1: $1 \to I$

Page 92, line 5: $\mathcal{F}_0 \to \mathcal{F}^0$

Page 99, line 17: $\pi^{-n/4}\exp(-\frac{1}{2}\sum \omega_j^2 x_j^2) \to (\omega_1 \cdots \omega_n)^{1/4}\pi^{-n/4}\exp(-\frac{1}{2}\sum \omega_j x_j^2)$

Page 99, line 19: $n_1 + \cdots + n_K + \frac{1}{2}K \to \sum \omega_j(n_j + \frac{1}{2})$

Page 100, line −14: $u_{kj}A^\dagger_j \to u_{jk}A^\dagger_k$

Page 101, line 9: All A_j should be $A_j(t)$.

Page 105, line −3: $g \to v$

Page 109, line 4: $\iint \quad \to \quad \int$

Page 109. formula (5.22): $a^* \quad \to \quad a^\dagger$

Page 113, 2nd line below 2nd display: $= v \quad \to \quad = mv$ in the last two equations

Page 115, display below (5.35): $\epsilon \quad \to \quad e$

Page 116, 3rd line above (5.38): a an → a

Page 118, Concluding remarks, line 11: an → a

Page 119, Axiom 3: The set → The linear span of the set

Page 125, line 6: $\|H_I\|^n/n! \quad \to \quad \|H_I\|^n t^n/n!$

Page 126, line 1: 0.9902065 → 0.99019424

Page 129, line 8: $\mathcal{H}_{\text{field}} \quad \to \quad H_{\text{field}}, \qquad a^* \quad \to \quad a^\dagger$

Page 129, line before (6.13): $x \quad \to \quad \mathbf{x}$

Page 129, formula (6.13): Insert $\dfrac{1}{L^{3/2}}$ before the summation.

Page 129, 2nd line after (6.13): $x \quad \to \quad \mathbf{x}$ (3 places), and omit the $\otimes$ on the right. (The following sentence explains the intended meaning.)

Page 129, 4th line after (6.13): $\phi(\cdot) \quad \to \quad g\phi(\cdot)$

Page 129, line −7: $a_{\mathbf{p}} \quad \to \quad a(\mathbf{p})$ and $a_{\mathbf{p}}^\dagger \quad \to \quad a^\dagger(\mathbf{p})$

Page 130, first display: $a^* \quad \to \quad a^\dagger$ (several places)

Page 130, lines −7 and −6: $\langle m, \mathbf{p}|n\rangle \quad \to \quad \langle m, \mathbf{p}|U_0(t)|n\rangle$

Page 130, line −2: Insert factor of $\dfrac{1}{i}$.

Page 134, 2nd and 3rd lines after (6.20): $\nabla - \mathbf{p} \quad \to \quad \nabla - i\mathbf{p}$

Page 134, formula (6.21), two lines above, and three lines below: $\mathbf{p}\cdot\nabla/M \quad \to \quad \mathbf{p}\cdot\nabla/iM$

Page 137, line −3: $t_n \quad \to \quad \tau_n$

Page 138, line −4: Insert a factor of $\dfrac{1}{i}$ before the second integral.

Page 140, formula (6.29): $-\frac{1}{2}(\partial\phi)^2 \quad \to \quad +\frac{1}{2}(\partial\phi)^2$

Page 149, 4 lines above (6.49): $e^{itp_\mu x^\mu} \quad \to \quad e^{ip_\mu x^\mu}$

Page 151, 5th line after (6.53): $D_{\mu\nu}q^\nu \quad \to \quad D_{\mu\nu}p^\nu$

Page 152, line 3: $q_\mu q_\nu \quad \to \quad p_\mu p_\nu$

Page 152, line 15: it → if

Page 152, line −14: Insert "and likewise with $\phi(y)$ replaced by $\phi^\dagger(y)$," after "spacelike,".

Page 156, line 12: (1) → (i)

Page 158, line −11: $\Delta_F(0) \quad \to \quad -i\Delta_F(0)$

Page 160, line 4: $y,, \quad \to \quad y,$

Page 160, first line of (vi): (5) → (v)

Page 165, Table 6.2: v should be $\overline{v}$ for incoming positrons; $\overline{v}$ should be v for outgoing positrons.

Page 169, line 14: $V^{1/2}a_{\mathcal{B}}^{\dagger}(\mathbf{p}_1) \quad\to\quad V^{1/2}a_{\mathcal{B}}^{\dagger}(\mathbf{p}_1)|0\rangle$ and $V^{1/2}a_{\mathcal{B}}^{\dagger}(\mathbf{p}_2) \quad\to\quad V^{1/2}a_{\mathcal{B}}^{\dagger}(\mathbf{p}_2)|0\rangle$.

Page 171, line 9: particles $\to$ describe particles

Page 171, 2nd line after (6.70): coutgoing $\to$ outgoing

Page 191: Add the following clause to the end of the first sentence of item 2: "while preserving essential structural features such as Lorentz covariance".

Page 192, 2nd paragraph of section 7.1, next-to-last line: $n\delta^{(n-1)}(t) \quad\to\quad -n\delta^{(n-1)}(t)$

Page 193, line −4: $-\Gamma'(1) \quad\to\quad \Gamma'(1)$

Page 193, third display: The integrand of the second integral should be $\phi(t)|t|^z$.

Page 197, line 1: Delete one copy of "*superficial degree of divergence*".

Page 211, 3rd paragraph of section 7.5, line 2: Insert space before "that".

Page 212, third display: $m^2\phi^2 \quad\to\quad \frac{1}{2}m^2\phi^2$

Page 229, formula (7.56): $\Gamma^\mu(q,p) \quad\to\quad \Gamma^\mu(p',p)$

Page 231, line −3: Brehmsstrahlung $\to$ Bremsstrahlung

Page 235, line 7: $A^{-(d-4)/2} \quad\to\quad A^{-(4-d)/2}$

Page 235, display (7.64): Delete the 2 before the integral sign.

Page 244, line −1: $q_\mu \quad\to\quad k_\mu$

Page 245, formula (7.77): $(1-x)^2 \quad\to\quad (1-x)^2m^2$

Page 245, line 8: $2p \quad\to\quad 2p^\mu$

Page 245, formula (7.78): $(2m^2+1-x) \quad\to\quad 2m^2x(1-x)$

Page 254, line 16: constitutent $\to$ constituent

Page 258, 2nd line after (8.12): Thie $\to$ The

Page 264, third display: $dx_n \quad\to\quad dx_N$

Page 266, 3rd display, line 1: Insert C before the first integral sign.

Page 269, formula (8.17): $x_j \quad\to\quad x_J$

Page 273, line 5: $dx \quad\to\quad d^4x$

Page 274, line −4: evaulated $\to$ evaluated

Page 286, line 3: [??, vol. 4] $\to$ [51]

Page 288, line 14: $e^{-Ay\cdot y}/2 \quad\to\quad e^{-Ay\cdot y/2}$

Page 291: Add the following sentence to the end of the first paragraph: "The quantum connection comes from the way Feynman diagrams can be read off from the Lagrangian, as explained in §§6.4–6.6."

Page 296, last paragraph of §9.1: Replace this paragraph by the following:

> There is an easy and important generalization of the gauge field theory discussed above. As a first step, instead of starting with $G \subset GL(n,\mathbb{C})$, one can start with an abstract compact Lie group G and a representation $\pi : G \to GL(n,\mathbb{C})$. The gauge field A_μ is still $\mathfrak{g}$-valued; $g\cdot\Phi$ is interpreted as $\pi(g)\Phi$, and the covariant derivative is $\partial_\mu + i\pi'(A_\mu)$ where π' is the derived representation of $\mathfrak{g}$. In this setting, there can be several different Φ's, say $\Phi^1,\ldots,\Phi^K$ (where Φ^k is an n_k-tuple), each with its

own G-action $\pi_k : G \to GL(n_k, \mathbb{C})$ and its own free Lagrangian $\mathcal{L}^k(\Phi^k, \partial\Phi^k)$. One then obtains a theory in which all of these fields are coupled to the gauge field A_μ by taking the Lagrangian to be

$$\sum_1^K \mathcal{L}^k(\Phi^k, (\partial + i\pi_k'(A))\Phi^k) - \tfrac{1}{4}\langle F_{\mu\nu}|F^{\mu\nu}\rangle.$$

For example, if $G = U(1)$ and π_k is the irreducible representation $\pi(e^{i\theta}) = e^{im_k\theta}$, the derived representation of $\mathfrak{g} = i\mathbb{R}$ is $\pi_k'(ix) = im_k x$, so the field Φ^k couples to A_μ with strength proportional to m_k. In this way, or in a more general setting where G contains a $U(1)$ factor, the theory can accommodate particles with different electric charges (all integer multiples of some fundamental charge). We shall see this idea at work in §9.4.

Page 301, line −15: $\gamma(\eta) \quad \to \quad g(\eta)$

Page 302, display (9.7): n (upper limit of summation) $\quad \to \quad$ N (two places)

Page 304, 4th line after (9.10): $e + \nu_\mu + \overline{\nu}_\mu \quad \to \quad e + \nu_\mu + \overline{\nu}_e$

Page 313, line 4: third $\quad \to \quad$ second

Page 313, line −10: $Y(d_L) = -\frac{1}{3} \quad \to \quad Y(d_R) = -\frac{1}{3}$

Page 324: Insert the entry "line width, 131".

Page 325: Insert the entry "superficial degree of divergence, 197".

Note: Readers may be interested in the book *Finite Quantum Electrodynamics* by G. Scharf (2nd ed., Springer, Berlin, 1995). It develops the Dyson series for the S-matrix of QED in a way that avoids divergent integrals, by replacing the usual time-ordered products by a construction with better regularity properties.