AN UPDATED LIST OF ERRATA

QUANTUM FIELD THEORY

C. Itzykson and J.-B. Zuber

October 2005

CHAPTER I

Page 16, line 1, after "force law ", add "it follows that "

Page 16, line 3, instead of " we learn ... "
read " This expression holds for a weak magnetic field when we average over the motion of the orbiting particle. It amounts to dropping total time derivatives, and shows ... "

Page 20, eq. (1-88), instead of " $\frac{\partial I}{\partial t_2} - \frac{\partial I}{\partial t_1} = 0$ " read " $\frac{\partial I}{\partial t_2} + \frac{\partial I}{\partial t_1} = 0$ "

Page 23, eq. (1-97),
instead of " $\widetilde{\Theta}^{\mu\nu} = \frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi_i)} \partial_\nu \phi_i - g_{\mu\nu} \mathcal{L}$ ", read " $\widetilde{\Theta}^{\mu\nu} = \frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi_i)} \partial^\nu \phi_i - g^{\mu\nu} \mathcal{L}$ "

Page 27, eq. (1-131),
instead of " $\pi(\mathbf{x}, t) = \frac{\partial L}{\partial \partial_0 \varphi(\mathbf{x}, t)} = \cdots$", read " $\pi(\mathbf{x}, t) = \frac{\delta L}{\delta \partial_0 \varphi(\mathbf{x}, t)} = \cdots$ "

Page 31, eq. (1-158)
instead of " $J^\mu = j^\mu + \frac{\partial \mathcal{L}_{\text{int}}}{\partial[\partial_\mu \alpha(x)]} = \cdots$ " read " $J^\nu = j^\nu + \frac{\partial \mathcal{L}_{\text{int}}}{\partial[\partial_\nu \alpha(x)]} = \cdots$ "

Page 33, eq. (1-169)
instead of " $\widetilde{G}_{\substack{\text{ret} \\ \text{adv}}}(p) = \frac{-1}{(p_0 \pm i\varepsilon) - \mathbf{p}^2 - m^2}$ " read " $\widetilde{G}_{\substack{\text{ret} \\ \text{adv}}}(p) = \frac{-1}{(p_0 \pm i\varepsilon)^2 - \mathbf{p}^2 - m^2}$ "

Page 34, eq. (1-172), instead of "$e^{\pm i\omega_p x_0 + \cdots}$ " read "$e^{\mp i\omega_p x_0 + \cdots}$ "

Page 35, last line, instead of " Sec. 1-2 " read " Sec. 1-1-2 "

Page 41, eq. (1-212), instead of " $\cdots = -j.\widetilde{j}^*$ " read " $\cdots = -\widetilde{j}.\widetilde{j}^*$ "

CHAPTER II

Page 47, eq. (2-3)
instead of " $\left(\frac{\partial^2}{\partial t^2} - \boldsymbol{\nabla}^2 - m^2\right) \psi(\mathbf{x}, t) = 0$ " read " $\left(\frac{\partial^2}{\partial t^2} - \boldsymbol{\nabla}^2 + m^2\right) \psi(\mathbf{x}, t) = 0$ "

Page 59, eq. (2-50)
instead of " $P(n_k)\Lambda_\pm(k) = \left(I \pm \frac{\boldsymbol{\Sigma}.\mathbf{k}}{|\mathbf{k}|}\right) \Lambda_\pm(k)$ " read " $P(n_k)\Lambda_\pm(k) = \frac{1}{2}\left(I \pm \frac{\boldsymbol{\Sigma}.\mathbf{k}}{|\mathbf{k}|}\right) \Lambda_\pm(k)$ "

Page 60, eq. (2-51)
instead of " $\frac{\not{k}+m}{2}$ " read " $\frac{\not{k}+m}{2m}$ "; instead of " $\frac{-\not{k}+m}{2}$ " read " $\frac{-\not{k}+m}{2m}$ "

Page 61, line –9, instead of " b/d^* " read " d^*/b "

Page 66, lines 5, 7 and 12 , instead of " $\frac{e\hbar}{2mc}$ " read $\frac{e\hbar}{2m}$ "

Page 66, line 7, instead of " $\frac{e\hbar}{mc}$ " read $\frac{e\hbar}{m}$ "

Page 82, line 13, instead of " $\dfrac{mZ^4\alpha^5}{n^3}$ " read " $\dfrac{mZ^4\alpha^5}{\pi n^3}$ "

Page 84, line 1,
instead of " $E_{\rm tot} = m+M-\dfrac{\alpha}{2n^2}\dfrac{mM}{m+M}+\cdots$ " read " $E_{\rm tot} = m+M-\dfrac{\alpha^2}{2n^2}\dfrac{mM}{m+M}+\cdots$ "

Page 93, eq. (2-118)
instead of "$e\int d^4x_2\, A\!\!\!/(x_2)S_A(x_2,x_1)$ " read "$e\int d^4x_2\, S_F(x_3,x_2)A\!\!\!/(x_2)S_A(x_2,x_1)$ "

CHAPTER III

Page 109, eq. (3-16), last line
instead of " $[a_k, a_{k'}] = \delta(k-k')$ " read " $[a_k, a^\dagger_{k'}] = \delta(k-k')$ "

Page 117, eq. (3-56), instead of " $\Delta(x-y) = \cdots$ " read " $\Delta(x) = \cdots$ "

Page 119, second line
instead of " $D(\eta_2)|\eta_1) = |\eta_1+\eta_2)$ " read " $D(\eta_2)|\eta_1) = e^{i\int d\widetilde{k}\,{\rm Im}(\eta_1^*\eta_2)}|\eta_1+\eta_2)$ "

Page 119, eq. (3-67)
instead of "$\widetilde{f}_n(k) = \int d^3x\, e^{i\mathbf{k}.\mathbf{x}}F_n(\mathbf{x}) = \widetilde{F}_n(\mathbf{k})$", read "$\widetilde{f}_n(k) = \int d^3x\, e^{-i\mathbf{k}.\mathbf{x}}F_n(\mathbf{x}) = \widetilde{F}_n(\mathbf{k})$"

Page 120, eq. (3-69)
instead of "$\varphi_c(\mathbf{x}) = \sum_n \varphi_{n,c}\int d\widetilde{k}\, e^{-i\mathbf{k}.\mathbf{x}}F_n^*(\mathbf{k})$", read "$\varphi_c(\mathbf{x}) = \sum_n \varphi_{n,c}\int d\widetilde{k}\, e^{-i\mathbf{k}.\mathbf{x}}\widetilde{F}_n^*(\mathbf{k})$"

Page 135, eq. (3-136), end of first line
instead of " $k^0 = \sqrt{k^2+\mu^2}$ " read " $k^0 = \sqrt{\mathbf{k}^2+\mu^2}$ "

Page 135, line –6, first part of the equation
instead of " $\varepsilon^{(\lambda)}(k).\varepsilon^{(\lambda')}(k) = \delta_{\lambda\lambda'}$ " read " $\varepsilon^{(\lambda)}(k).\varepsilon^{(\lambda')}(k) = -\delta_{\lambda\lambda'}$ "

Page 140, line 11, instead of " $u = a^2k^2/\pi$ " read " $u = a^2k^2/\pi^2$ "

Page 149, eq. (3-169), instead of " $\{\psi_\xi(x), \bar\psi_{\xi'}(x')\} = \cdots$ ", read " $\{\psi_\xi(x), \bar\psi_{\xi'}(y)\} = \cdots$ "

Page 153, line 5, instead of " $C = i\gamma^0\gamma^2$ " read " $C = i\gamma^2\gamma^0$ "

Page 156, line 17, instead of " $\gamma^5Cu^*(\hat{k},\varepsilon) = \cdots$ " read " $\gamma^5Cu^*(\widetilde{k},\varepsilon) = \cdots$ "

Page 159, line –6
instead of " $\gamma^0O^\mu(p',p)^\dagger\gamma^0 = O^\mu(p',p)$ " read " $\gamma^0O^\mu(p',p)^\dagger\gamma^0 = O^\mu(p,p')$ "

Page 160, line 6, in the bracket of Eq. (3.203), add a fourth term $+\gamma^5(q^2\gamma^\mu - q\!\!\!/ q^\mu)F_4(q^2)$

Page 160, lines 10-11
instead of " $F_3(q^2) = -F_3(q^2)$. Thus parity conservation alone yields $F_3 = 0$."

read “ $F_3(q^2) = -F_3(q^2)$ and $F_4(q^2) = -F_4(q^2)$. Thus parity conservation alone yields $F_3 = F_4 = 0$.”

Page 160, lines 14, instead of “$\epsilon_1 = \epsilon_2 = -\epsilon_3 = 1$.” read “$\epsilon_1 = \epsilon_2 = -\epsilon_3 = \epsilon_4 = 1$.”

Page 161, line 2, instead of “ $\sigma^{\mu\nu} = \frac{i}{2}[^{\gamma\mu}, \gamma^\nu]$ ” read “ $\sigma^{\mu\nu} = \frac{i}{2}[\gamma^\mu, \gamma^\nu]$ ”

CHAPTER IV

Page 179, line 17, instead of “ $\sum_{1\le k<l\le N}$ ” read “ $\sum_{1\le l<k\le N}$ ”

Page 188, line 15, instead of “ $\mathcal{F}(A)$ ” read “ $\mathcal{T}(A)$ ”

Page 193, eq. (4-113), line 1, instead of “ $(P-eA)^2-m^2 = \cdots$” read “ $(P-eA)^2 = \cdots$”

CHAPTER V

Page 207, first line of eq. (5-28)
instead of “ $\langle p_1, \ldots, p_n, \text{in}|S|q_1, \ldots, q_l, \text{out}\rangle$ ” read “ $\langle p_1, \ldots, p_n, \text{in}|S|q_1, \ldots, q_l, \text{in}\rangle$ ”

Page 209, line 4, instead of “ $\cdots = \frac{a^{\dagger m}|0\rangle\langle 0|a^n}{m!n!}\cdots$ ” read “ $\cdots = \sum_{m,n=0}^{\infty} \frac{a^{\dagger m}|0\rangle\langle 0|a^n}{m!n!}\cdots$ ”

Page 215, line –5, middle line of the equation
instead of “ $\cdots - iZ^{-1/2}\int d^3x \cdots$ ” read “ $\cdots - iZ^{-1/2}\int d^4x \cdots$ ”

Page 222, eq. (5-88), instead of “ $\varepsilon_i.j(x)$ ” read “ $\varepsilon_i.j(y)$ ”

Page 223, line 12,
delete “, using the fact that $W_M(x-y)$ depends only on $(x-y)^2$ ”

Page 225, line –6, instead of “ $\cdots b^\dagger(q_i, \alpha_i)|0\rangle$ ” read “ $\cdots b^\dagger(p_i, \alpha_i)|0\rangle$ ”

Page 228, line –3, instead of “ $= 8k_i.p_i\, k_f.p_f\,[\cdots$ ” read “ $= 8k_i.p_i\, k_f.p_i\,[\cdots$ ”

Page 232, eq. (5-120), instead of “ $-4(\varepsilon_1.\varepsilon_2)$ ” read “ $-4(\varepsilon_1.\varepsilon_2)^2$ ”

Page 239, line –3, instead of “ $\cdots(\not p_f + \not k + m)\gamma^0(\not p_f + \not k + m)\cdots$ ”
read “ $\cdots(\not p_f + \not k + m)\gamma^0(\not p_i + m)\gamma^0(\not p_f + \not k + m)\cdots$ ”

Page 240, line 3, instead of “ $\cdots p_i.k\, p_j.k]$ ” read “ $\cdots p_i.k\, p_f.k]$ ”

Page 240, third line of eq. (5-150)
instead of “ $2\omega^2 \frac{p_i^2 \sin^2\theta_i + p_f^2 \sin^2\theta_f}{(E_f - p_f\cos\theta_f)(E_i - p_i\sin\theta_i)}$ ”, read “ $2\omega^2 \frac{p_i^2 \sin^2\theta_i + p_f^2 \sin^2\theta_f}{(E_f - p_f\cos\theta_f)(E_i - p_i\cos\theta_i)}$ ”

Page 246, line 9, instead of “ …complex field φ to describe … ”
read “ …complex field φ, creating A and annihilating $\overline{A}$, to describe … ”

CHAPTER VI

Page 278, eq. (6-39), instead of “ $\dfrac{m^2e^4}{4E^2(2\pi)^2}$ ” read “ $\dfrac{m^4e^4}{4E^2(2\pi)^2}$ ”

Page 281, eq. (6-47)
instead of “ $\dfrac{\alpha}{2E^2}\left[\dfrac{5}{4} - \dfrac{8E^4 - m^4}{E^2(E^2-m^2)(1-\cos\theta)} + \cdots\right.$ ”
read “ $\dfrac{\alpha^2}{2E^2}\left[\dfrac{5}{4} - \dfrac{8E^4 - m^4}{4E^2(E^2-m^2)(1-\cos\theta)} + \cdots\right.$ ”

Page 286, one line before eq. (6-65)
instead of “ $|\mathcal{T}|^2 = 4[\cdots]$ ” read “ $|\mathcal{T}|^2 = 4[\cdots]^2$ ”

Page 290, line –7, instead of “ $i\dfrac{\delta}{\partial\varphi_c(x)}$ ” read “ $i\dfrac{\delta}{\delta\varphi_c(x)}$ ”

Page 294, line 10, instead of “ Sec. 4-3 ” read “ Sec. 4-2-2 ”

Page 298, line –2, instead of “ $2L - 4V + 4 < 0$ ” read “ $2I - 4V + 4 < 0$ ”

Page 303, line –4, instead of “ $z_i = z_j^0$ ” read “ $z_j = z_j^0$ ”

Page 311, four lines after eq. (6-119)
instead of “ after elimination of $\alpha_1 = 1 - \alpha_2 - \alpha_3$, yield, for $\alpha = \alpha_2 = \alpha_3$ ($0 < \alpha < \frac{1}{2}$ since $0 < \alpha_1 < 1$) ”
read “ after elimination of $\alpha_3 = 1 - \alpha_1 - \alpha_2$, yield, for $\alpha = \alpha_1 = \alpha_2$ ($0 < \alpha < \frac{1}{2}$ since $0 < \alpha_3 < 1$) ”

CHAPTER VII

Page 326, line 10, instead of “ $\log(\Lambda^2/m^2)$ ” read “ $\ln(\Lambda^2/m^2)$ ”

Page 328, line 17, instead of “ Sec. 6-3-2 ” read “ Sec. 7-3-2 ”

Page 333, line –10
instead of “ ...ultraviolet divergent. ” read “ ...ultraviolet convergent. ”

Page 345, line –11, instead of “ Sec. 3-3-4 ” read “ Sec. 4-3-4 ”

Page 354, line –2
instead of “ $\varphi\tanh\varphi + (1 - \varphi\tanh\varphi)$ ” read “ $\frac{1}{2}\varphi\tanh\varphi + (1 - \varphi\coth\varphi)$ ”

Page 355, line 8, instead of “contributions ” read “contribution ”

Page 361, line –10, instead of “ $B = \dfrac{\alpha}{4\pi^2}\cdots$ ” read “ $B = \dfrac{\alpha}{2\pi^2}\cdots$ ”

Page 370, line –5, instead of “ vol. 75, p. 1912, ” read “ vol. 75, p. 898, ”

CHAPTER VIII

Page 377, line 9
instead of " $\frac{k_\mu k_\nu \delta^{\mu\nu} - m_2^2}{[(p-k)^2 - m_1^2]^n (k^2 - m_2^2)^p}$ " read " $\frac{k_\mu k_\nu \delta^{\mu\nu} + m_2^2}{[(p-k)^2 + m_1^2]^n (k^2 + m_2^2)^p}$ "

instead of " $\frac{1}{[(p-k)^2 - m_1^2]^n (k^2 - m_2^2)^{p-1}}$ " read " $\frac{1}{[(p-k)^2 + m_1^2]^n (k^2 + m_2^2)^{p-1}}$ "

Page 380, line 17, instead of " Therefore ω_v is " read " Therefore $\hat{\omega}_v$ is "

Page 381, line 8, instead of " at least an ... " read " at least one ... "

Page 383, eq. (8-23), instead of " $\cdots = 2L_l - 4I_l$ " read " $\cdots = 4L_l - 2I_l$ "

Page 408, end of eq. (8-78), instead of " $A_\sigma(x)|0\rangle$ " read " $A_\sigma(0)|0\rangle$ "

Page 409, line 6, instead of " $-i\frac{M^2}{\mu^2(k^2-M^2)}$ " read " $-i\frac{M^2 k_\sigma}{\mu^2(k^2-M^2)}$ "

Page 409, line 13, instead of " $B(k^2) = \lambda\frac{k^2-M^2}{k^2}$ " read " $B(k^2) = -\lambda\frac{k^2-M^2}{k^2}$ "

Page 410, line 5, instead of " Contracting Eq. (8-83) with k_σ and ... "
read " Contracting Eq. (8-83) with q_σ and ... "

Page 410, last line, instead of " p_1, p_2, p_3, p_4 " read " k_1, k_2, k_3, k_4 "

Page 413, line –6, instead of " $+eZ_1\bar{\psi}\not{A}\psi$ " read " $-eZ_1\bar{\psi}\not{A}\psi$ "

Page 421, eq. (8-124), instead of " C_2 " read " C_1 "

Page 421, line –7, instead of " $[\cdots]^{d/2-4}$ " read " $[\cdots]^{d-4}$ "

CHAPTER IX

Page 430, line –3
instead of " $M_{k,k+1} = M_{k-1,k} = \cdots \qquad 1 \le k \le n-1$ "
read " $M_{k,k+1} = M_{k+1,k} = \cdots \qquad 0 \le k \le n-1$ "

Page 437, eq. (9-46), instead of " $A = \sum_{n,m} A_{n,m} \cdots$ " read " $A = \sum_{n,m} \frac{A_{n,m}}{\sqrt{n!m!}} \cdots$ "

Page 438, line 2
instead of " $\exp\left[\bar{z}_n z_{n-1} - \sum_1^{n-1} \bar{z}_k z_k + \bar{z}_1 z_0 - i \cdots\right]$ " read " $\exp\left[\sum_0^{n-1} \bar{z}_{k+1} z_k - \sum_1^{n-1} \bar{z}_k z_k - i \cdots\right]$ "

Page 438, line 10, instead of " which requires to " read " which requires us to "

Page 442, eq. (9-77), instead of " $\frac{\bar{\eta}\dot{\eta} - \dot{\bar{\eta}}\eta}{2i}$ " read " $\frac{\dot{\bar{\eta}}\eta - \bar{\eta}\dot{\eta}}{2i}$ "

Page 459, after eq. (9-155), instead of " A canonical ... "
read " Requiring that the g's have vanishing Poisson brackets, a canonical ... "

Page 471, line 8
instead of " integrate the normalized version of $\dot{\tilde{\varphi}}$ in the subspace orthogonal to ψ. "
read "integrate in the subspace orthogonal to ψ, the normalized version of $\dot{\tilde{\varphi}}$. "

CHAPTER X

Page 480, interchange figures 10-3 and 10-4 but **not** their captions.

Page 480, eq. (10-24), instead of " $S(x_1, y_1; x_2, y_2; J)|_{J=0}$", read " $S(x_1, x_2; y_1, y_2; J)|_{J=0}$ "

Page 492, eq. (10-72), instead of " $D^{-3}\chi(P)$ " read " $D^{-3}\chi(p)$ "

Page 497, line 9, instead of " $p_0 = \mp E/2 + \omega - i\varepsilon$ " read " $p_0 = \mp E/2 - \omega - i\varepsilon$ "

Page 499, line –7, instead of " $(E'-E) \int d^3p\, \eta^\dagger(\mathbf{p})\varphi(\mathbf{p})$", read " $(E'-E) \int d^3p\, \eta^\dagger(\mathbf{p})\varphi'(\mathbf{p})$"

Page 499, eq. (10-107), instead of " $\eta^*(\mathbf{p})$ " read " $\eta^\dagger(\mathbf{p})$ "

Page 504, second line of eq. (10-120), instead of " $(k^0+m^2)-\cdots$ " read " $(k^0+m)^2-\cdots$"

CHAPTER XI

Page 523, lines 4-6, instead of " the lagrangian reads ... decoupled massless fields, "
read " the lagrangian has the form

$$\mathcal{L} = \tfrac{1}{2}(\partial\rho)^2 + \tfrac{1}{2}(\partial\boldsymbol{\xi})^2\left(1+\tfrac{\rho}{v}\right)^2\left(1+f\left(\tfrac{\boldsymbol{\xi}}{v}\right)\right) - \tfrac{\mu^2}{2}(v+\rho)^2 - \tfrac{\lambda}{4}(v+\rho)^4$$

with some function f. From this we see that the $\boldsymbol{\xi}$ correspond to $(n-1)$ massless fields,"

Page 547, last equation before Figure 11-13
instead of " $\cdots = \delta^4(x-y)\, T^\alpha_{kl}[\phi_l(y)+v_l]$ " read " $\cdots = -i\delta^4(x-y)\, T^\alpha_{kl}[\phi_l(y)+v_l]$ "

Page 551, replace lines 1-5 by
" At $k_1^2 = k_2^2 = 0$, hence $k_1.q = k_2.q = k_1.k_2$, only two independent tensors are consistent with these requirements :

$$\mathcal{B}_{1\,\mu\nu\rho} = \varepsilon_{\mu\nu\sigma\tau}k_1^\sigma k_2^\tau q_\rho$$

and $$\mathcal{B}_{2\,\mu\nu\rho} = (\varepsilon_{\mu\rho\sigma\tau}k_{1\,\nu} - \varepsilon_{\nu\rho\sigma\tau}k_{2\,\mu})\,k_1^\sigma k_2^\tau - \varepsilon_{\mu\nu\rho\sigma}(k_1^\sigma - k_2^\sigma)\,k_1.k_2\ .$$

A third possible tensor $\mathcal{B}_{3\,\mu\nu\rho} = (\varepsilon_{\mu\rho\sigma\tau}k_{2\,\nu} - \varepsilon_{\nu\rho\sigma\tau}k_{1\,\mu})k_1^\sigma k_2^\tau$ is actually not independent, because of the identity $q_\sigma\varepsilon_{\tau\mu\nu\rho} + q_\rho\varepsilon_{\sigma\tau\mu\nu} + q_\nu\varepsilon_{\rho\sigma\tau\mu} + q_\mu\varepsilon_{\nu\rho\sigma\tau} + q_\tau\varepsilon_{\mu\nu\rho\sigma} = 0$. This expresses that a totally antisymmetric rank 5 tensor vanishes in four dimensions. Contracted with $k_1^\sigma k_2^\tau$, this yields $\mathcal{B}_{1\,\mu\nu\rho} = \mathcal{B}_{2\,\mu\nu\rho} + \mathcal{B}_{3\,\mu\nu\rho}$. We therefore write the following expression when $k_1^2 = k_2^2 = 0$

$$\begin{aligned} T_{\mu\nu\rho}(k_1,k_2) &= \varepsilon_{\mu\nu\sigma\tau}k_1^\sigma k_2^\tau q_\rho T_1(q^2) \\ &\quad + \left[(\varepsilon_{\mu\rho\sigma\tau}k_{1\,\nu} - \varepsilon_{\nu\rho\sigma\tau}k_{2\,\mu})\,k_1^\sigma k_2^\tau - \varepsilon_{\mu\nu\rho\sigma}(k_1^\sigma - k_2^\sigma)\,k_1.k_2\right] T_2(q^2)\ . \end{aligned} \qquad (11-188)$$

Consequently,

$$q^\rho T_{\mu\nu\rho} = \varepsilon_{\mu\nu\sigma\tau}k_1^\sigma k_2^\tau q^2\left[T_1(q^2) + T_2(q^2)\right] \qquad (11-189)$$ "

Page 553, line 7, an updated value is $\Gamma^{\exp} = (7.75 \pm 0.5)\,\text{eV}$.

CHAPTER XII

Page 564, line 6, instead of " $s(0) = x_1, s(1) = x_2$ " read " $x(0) = x_1, x(1) = x_2$ "

Page 574, line –13, instead of " the latter " read " Γ "

Page 577, line 12, instead of " $\mathcal{M}_0 = -\Delta\delta_{ij}\cdots$ " read " $\mathcal{M}_0 = -\Delta\delta_{ab}\cdots$ "

Page 595, replace lines 1–7 in small characters by the following, also in small characters

To be precise we write $\det \mathcal{M}_{\mathcal{F}}(A) \equiv \Delta_{\mathcal{F}}(A, \mathcal{F}(A))$ according to the definition

$$\Delta_{\mathcal{F}}^{-1}(A, C) = \int \mathcal{D}(g)\,\delta(\mathcal{F}({}^gA) - C)$$

For a gauge transformation independent of A we have obviously

$$\Delta_{\mathcal{F}}\,({}^gA, C) = \Delta_{\mathcal{F}}(A, C)$$

due to the group invariance of the measure $\mathcal{D}(g)$. In the present case however where

$$A' = {}^{g(A)}A \qquad \mathcal{F}(A) = \mathcal{F}'(A') = \mathcal{F}'\left({}^{g(A)}A\right)$$

the gauge transformation depends on the potential. We shall show that the jacobians in $\mathcal{D}(A)$ and $\Delta_{\mathcal{F}}$ conspire to cancel. Consider

$$\int \mathcal{D}(A)\Delta_{\mathcal{F}}(A, \mathcal{F}(A)) = \int \mathcal{D}(A)\Delta_{\mathcal{F}}(A, \mathcal{F}(A)) \left[\int \mathcal{D}(A')\,\delta\left(A' - {}^{g(A)}A\right)\right]$$
$$\times \left[\Delta_{\mathcal{F}'}(A, \mathcal{F}(A)) \int \mathcal{D}(g)\,\delta\left(\mathcal{F}'\,({}^gA) - \mathcal{F}(A)\right)\right]$$

Both terms between brackets on the right hand side are equal to unity. The argument of the last δ-function vanishes for $g = g(A)$, we can therefore substitute the generic g for $g(A)$ in the first δ-function. We then set $A = {}^{g^{-1}}B$, recognize that $\mathcal{D}(A) = \mathcal{D}(B)$ and integrate over B. Thus, using the invariance of Δ under potential independent gauge transformations

$$\int \mathcal{D}(A)\,\Delta_{\mathcal{F}}(A, \mathcal{F}(A)) =$$
$$= \int \mathcal{D}(A')\mathcal{D}(g)\,\Delta_{\mathcal{F}}\left(A', \mathcal{F}\left({}^{g^{-1}}A'\right)\right)\Delta_{\mathcal{F}'}\left(A', \mathcal{F}\left({}^{g^{-1}}A'\right)\right)\delta\left(\mathcal{F}'(A') - \mathcal{F}\left({}^{g^{-1}}A'\right)\right)$$
$$= \int \mathcal{D}(A')\mathcal{D}(g)\,\Delta_{\mathcal{F}}(A', \mathcal{F}'(A'))\,\Delta_{\mathcal{F}'}(A', \mathcal{F}'(A'))\,\delta\left(\mathcal{F}'(A') - \mathcal{F}\left({}^{g^{-1}}A'\right)\right)$$
$$= \int \mathcal{D}(A')\,\Delta_{\mathcal{F}'}(A', \mathcal{F}'(A'))$$

The last equality follows from the integration over g and translates in precise terms Eq. (12-129).

Page 596, eq. (12-137), erase the first " 0= "

Page 600, line –10, instead of " $\widetilde{I}_1 = I - \cdots$ " read " $\widetilde{I}_1 = \widetilde{I} - \cdots$ "

Page 603, line –9, instead of " involve no λ_5 matrix " read " involve no γ_5 matrix "

Page 611, line –10, instead of " $(k^2 - m^2)^{-1}$ " read " $(k^2 - M^2)^{-1}$ "

Page 625, line 8, an updated value is $\sin^2\theta_W \simeq 0.23$.

CHAPTER XIII

Page 635, line 11
instead of "the derivative $(\partial/\partial x)d^{as}(\alpha_1, x)$ " read "the derivative $(\partial/\partial x)d^{as}(\alpha, x)$ "

Page 648, eq. (13-61), instead of " $\cdots = m_0 \dfrac{\partial}{\partial m_0} \cdots$ read " $\cdots = \frac{1}{2} m_0 \dfrac{\partial}{\partial m_0} \cdots$

Page 649, eq.(13-65), instead of " $\dfrac{\partial m_0(\Lambda/m, g)}{\partial m}$ " read " $\dfrac{\partial m_0(\Lambda/m, g_0)}{\partial m}$ "

Page 653, line –3, instead of " ...Migdal "
read " ...Migdal, as well as the three-loop one worked out by Tarasov, Vladimirov and Zharkov "

Page 653, line –2, instead of "$+O(g^7)$ "
read "$+\frac{g^7}{(4\pi)^6}\Big(-\frac{2857}{54}C^3 + \frac{1415}{27}C^2T_f - \frac{158}{27}CT_f^2 + \frac{205}{9}CC_fT_f - \frac{44}{9}C_fT_f^2 - 2C_f^2T_f\Big) + O(g^9)$ "

Page 660, line 14, instead of " . A mean " read " . A means "

Page 662, line –3, instead of "Experimental conditions, $\sin^2(\theta/2) \ll 1$, "
read "Experimental limitations on the accessible range of $\sin^2(\theta/2)$ "

Page 670, eq. (13-124), instead of " $m_\mu^2/q^2 \to \infty$ " read " $m_\mu^2/q^2 \to 0$ "

Page 676, eq. (13-144), instead of " $\int \frac{d^4p}{(2\pi)^4}$ " read " $\int \frac{d^4q}{(2\pi)^4}$ "

Page 683, line 4, instead of " which play " read " which plays "

Page 683, line –5
instead of " $W(q^2, -\omega) = -W(q^2, -\omega)$ " read " $W(q^2, -\omega) = -W(q^2, \omega)$ "

Page 689, line 9, add
" For the three-loop calculation, see O.V. Tarasov, A.A. Vladimirov and A.Yu. Zharkov, *Phys. Lett.*, ser. B, vol. 93, p. 429, 1980. "

APPENDIX

Page 696, line –2, eq. (A-40), instead of " $(2\pi^3)$ " read " $(2\pi)^3$ "

INDEX

Page 702, left column, line –6
instead of " paramagnetic representation " read " parametric representation "

Page 702, right column, line 26
instead of " Gell-Mann low function " read " Gell-Mann Low function "