Errata

Lectures on Electromagnetic Theory

Chapter 1 — Maxwell equations and uniqueness

p. 20 complex Poynting theorem, electric stored-energy term.

Reads:

$$\vec{\nabla}\cdot\vec{S}_c = -i2\omega\left(\frac{\mu|\vec{H}|^2}{4} - \frac{\epsilon|\vec{E}|^2}{4}\right) - \frac{\vec{E}\cdot\vec{J}^*}{2} - \frac{\vec{H}^*\cdot\vec{M}}{2}.$$

Should read:

$$\vec{\nabla}\cdot\vec{S}_c = -i2\omega\left(\frac{\mu|\vec{H}|^2}{4} - \frac{\epsilon^*|\vec{E}|^2}{4}\right) - \frac{\vec{E}\cdot\vec{J}^*}{2} - \frac{\vec{H}^*\cdot\vec{M}}{2}.$$

p. 21 energy identity and its surface-integral form (and the sentence introducing them).

Reads: the difference fields are dotted "… and the second with $\delta\vec{E}^*$," giving

$$\vec{\nabla}\times\delta\vec{E}\cdot\delta\vec{H}^* - \vec{\nabla}\times\delta\vec{H}\cdot\delta\vec{E}^* = \vec{\nabla}\cdot\left(\delta\vec{E}\times\delta\vec{H}^*\right) = i\omega\left(\mu|\delta\vec{H}|^2 - \epsilon|\delta\vec{E}|^2\right),$$

$$\oint_S\left(\delta\vec{E}\times\delta\vec{H}^*\right)\cdot d\vec{s} = i\omega\int_V\left(\mu|\delta\vec{H}|^2 - \epsilon|\delta\vec{E}|^2\right)dv.$$

Should read: "… and the *conjugate of the* second with $\delta\vec{E}$," giving

$$\vec{\nabla}\times\delta\vec{E}\cdot\delta\vec{H}^* - \vec{\nabla}\times\delta\vec{H}^*\cdot\delta\vec{E} = \vec{\nabla}\cdot\left(\delta\vec{E}\times\delta\vec{H}^*\right) = -i\omega\left(\mu|\delta\vec{H}|^2 - \epsilon^*|\delta\vec{E}|^2\right),$$

$$\oint_S\left(\delta\vec{E}\times\delta\vec{H}^*\right)\cdot d\vec{s} = -i\omega\int_V\left(\mu|\delta\vec{H}|^2 - \epsilon^*|\delta\vec{E}|^2\right)dv.$$

Chapter 2 — Plane waves and waveguides

p. 37 circular-polarization phase condition.

Reads:

$$|E_x| = |E_y|, \qquad \delta_x - \delta_y = \frac{n\pi}{2}, \qquad n\in\mathbb{Z}.$$

Should read:

$$|E_x| = |E_y|, \qquad \delta_x - \delta_y = \frac{(2m+1)\pi}{2}, \qquad m\in\mathbb{Z}.$$

p. 43 phase velocity in a low-loss medium.

Reads:

$$v_p = \frac{\omega}{\beta} = \left\{\frac{\mu\epsilon'}{2}\left[\sqrt{1+(\tan\delta)^2}-1\right]\right\}^{-1/2}.$$

Should read:

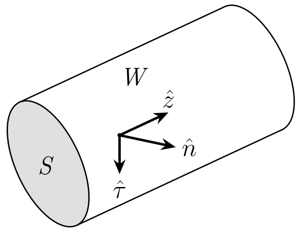
$$v_p = \frac{\omega}{\beta} = \left\{\frac{\mu\epsilon'}{2}\left[\sqrt{1+(\tan\delta)^2}+1\right]\right\}^{-1/2}.$$

p. 53 TE-mode boundary condition at a PEC wall.

Reads: $E^0_\tau = i\omega\mu\,\partial_n H^0_z$. *Should read:* $E^0_\tau = \dfrac{i\omega\mu}{k_c^2}\,\partial_n H^0_z$.

p. 54 Figure 2.5 (illustration of a waveguide cross section): direction of the $\hat{\tau}$ arrow.

Reads: $\hat{\tau}$ is drawn pointing *up*.
Should read: $\hat{\tau}$ should point the opposite way (*downward* along the wall): $\hat{\tau} = \hat{z} \times \hat{n}$.



p. 59 modal-orthogonality identity, Cases 1 and 2.

Reads:

$$\left(\hat{z} \times \vec{\nabla}_\perp \psi_{pq}\right) \cdot \left(\hat{z} \times \vec{\nabla}_\perp \psi_{p'q'}\right) = \hat{z} \cdot \left[\hat{z}\left(\vec{\nabla}_\perp \psi_{pq} \cdot \vec{\nabla}_\perp \psi_{pq}\right)\right] = \vec{\nabla}_\perp \psi_{pq} \cdot \vec{\nabla}_\perp \psi_{pq}.$$

Should read:

$$\left(\hat{z} \times \vec{\nabla}_\perp \psi_{pq}\right) \cdot \left(\hat{z} \times \vec{\nabla}_\perp \psi_{p'q'}\right) = \hat{z} \cdot \left[\hat{z}\left(\vec{\nabla}_\perp \psi_{pq} \cdot \vec{\nabla}_\perp \psi_{p'q'}\right)\right] = \vec{\nabla}_\perp \psi_{pq} \cdot \vec{\nabla}_\perp \psi_{p'q'}.$$

p. 60 triple-product identity, Case 3.

Reads: $(\hat{z} \times \vec{\nabla}_\perp \psi_{pq}) \cdot \hat{n} = \vec{\nabla}_\perp \psi_{pq} \cdot (\hat{z} \times \hat{n}) = -\vec{\nabla}_\perp \psi_{pq} \cdot \hat{\tau}$.
Should read: $(\hat{z} \times \vec{\nabla}_\perp \psi_{pq}) \cdot \hat{n} = \vec{\nabla}_\perp \psi_{pq} \cdot (\hat{n} \times \hat{z}) = -\vec{\nabla}_\perp \psi_{pq} \cdot \hat{\tau}$.

Chapter 3 — Radiation

p. 76 Hertzian dipole, the intermediate $\vec{\nabla}[\vec{\nabla} \cdot (\hat{z}G)]$.

Reads:

$$\vec{\nabla}\left[\vec{\nabla} \cdot (\hat{z}G)\right] = G\left[\left(-k^2 + \frac{2ik}{r} + \frac{1}{r^2}\right)\cos\theta\,\hat{r} + \left(ik + \frac{1}{r}\right)\sin\theta\,\hat{\theta}\right].$$

Should read:

$$\vec{\nabla}\left[\vec{\nabla} \cdot (\hat{z}G)\right] = G\left[\left(-k^2 + \frac{2ik}{r} + \frac{2}{r^2}\right)\cos\theta\,\hat{r} + \frac{1}{r}\left(ik + \frac{1}{r}\right)\sin\theta\,\hat{\theta}\right].$$

p. 82 rectangular-aperture far field, phase factor.

Reads: $\cdots e^{ik(x'u+y')}\,dx'\,dy'$. *Should read:* $\cdots e^{ik(x'u+y'v)}\,dx'\,dy'$.

p. 82 rectangular-aperture far field, amplitude prefactor.

Reads: $\vec{E} \approx ikE_0ab\,\frac{e^{-ikr}}{4\pi r}\,(\cdots)\ \mathrm{sinc}\left(\frac{ka}{2}u\right)\mathrm{sinc}\left(\frac{kb}{2}v\right)$.
Should read: $\vec{E} \approx ikE_0ab\,\frac{e^{-ikr}}{2\pi r}\,(\cdots)\ \mathrm{sinc}\left(\frac{ka}{2}u\right)\mathrm{sinc}\left(\frac{kb}{2}v\right)$.

Chapter 4 — Electromagnetic scattering

p. 91 cylindrical-wave (Jacobi–Anger) expansion, projection step.

Reads: “Multiplying [the expansion] by $e^{im\phi}$ and integrating over ϕ …”
Should read: “Multiplying [the expansion] by $e^{-im\phi}$ and integrating over ϕ …”

p. 96 separation of variables, scalar Helmholtz equation.

Reads: “… multiply $r^2 \sin\theta$ and divide it by ψ …” *Should read:* “… multiply $r^2 \sin^2\theta$ and divide it by ψ …”

p. 97 Legendre regularity condition.

Reads: “… remain finite at $\sin\theta = \pm 1$ …” *Should read:* “… remain finite at $\cos\theta = \pm 1$ …”

p. 100 incident-field Debye-potential expansion.

Reads: $\pi_e^i = \sum_{n=0}^{\infty} \sum_{m=0}^{n} j_n(k_2 r)\, P_n^m(\cos\theta)(A_{mn}\cos m\phi + B_{mn}\sin m\phi)$.
Should read: $\pi_e^i = \sum_{n=0}^{\infty} \sum_{m=0}^{n} j_n(kr)\, P_n^m(\cos\theta)(A_{mn}\cos m\phi + B_{mn}\sin m\phi)$.

p. 101 Riccati–Bessel identity.

Reads: $\frac{d^2}{dr^2}[r j_n(kr)] + (kr)^2 j_n(kr) = n(n+1) j_n(kr)$.

Should read: $\left(\frac{d^2}{dr^2} + k^2\right)[r j_n(kr)] = \frac{n(n+1)}{r}\, j_n(kr)$.

p. 98 and 104 second-kind spherical Hankel function (two occurrences).

Reads:

$$h_n^{(2)}(kr) = \sqrt{\frac{\pi}{2kr}}\, H_{n+1/2}(kr), \qquad \hat{h}_n^{(2)}(kr) = \sqrt{\frac{\pi kr}{2}}\, H_{n+1/2}(kr) \approx i^{n+1} e^{-ikr}.$$

Should read:

$$h_n^{(2)}(kr) = \sqrt{\frac{\pi}{2kr}}\, H_{n+1/2}^{(2)}(kr), \qquad \hat{h}_n^{(2)}(kr) = \sqrt{\frac{\pi kr}{2}}\, H_{n+1/2}^{(2)}(kr) \approx i^{n+1} e^{-ikr}.$$

p. 102 dielectric-sphere matching conditions (ϵ and μ interchanged in the algebraic continuity of the Debye potentials, and one undefined subscript).

Reads:

$$\mu\, \pi_e = \mu_d\, \pi_e^d, \qquad \epsilon\, \pi_{mr} = \epsilon_d\, \pi_m^d.$$

Should read:

$$\epsilon\, \pi_e = \epsilon_d\, \pi_e^d, \qquad \mu\, \pi_m = \mu_d\, \pi_m^d.$$

p. 103 dielectric-sphere internal Mie coefficients c_n, d_n (numerators).

Reads:

$$c_n = \frac{i\sqrt{\epsilon_d \mu}}{D_e}, \qquad d_n = \frac{i\sqrt{\epsilon \mu_d}}{D_m},$$

Should read:

$$c_n = \frac{i\, \mu_d \sqrt{\epsilon_d/\mu}}{D_e}, \qquad d_n = \frac{i\, \mu_d \sqrt{\epsilon_d/\mu}}{D_m},$$

p. 105 the $|S_1(\theta)|^2$ and $|S_2(\theta)|^2$ expansions (bodies interchanged, and one mis-paired term). With $c_n = (2n+1)/[n(n+1)]$:

Reads:

$$|S_1|^2 = \sum_{n,n'} c_n c_{n'} \left[a_n \tau_n a^*_{n'} \tau_{n'} + b_n \pi_n b^*_{n'} \pi_{n'} + a_n \tau_n b^*_{n'} \pi_{n'} + b_n \pi_n a^*_{n'} \pi_{n'} \right],$$

$$|S_2|^2 = \sum_{n,n'} c_n c_{n'} \left[a_n \pi_n a^*_{n'} \pi_{n'} + b_n \tau_n b^*_{n'} \tau_{n'} + a_n \pi_n b^*_{n'} \tau_{n'} + b_n \tau_n a^*_{n'} \pi_{n'} \right].$$

Should read:

$$|S_1|^2 = \sum_{n,n'} c_n c_{n'} \left[a_n \pi_n a^*_{n'} \pi_{n'} + b_n \tau_n b^*_{n'} \tau_{n'} + a_n \pi_n b^*_{n'} \tau_{n'} + b_n \tau_n a^*_{n'} \pi_{n'} \right],$$

$$|S_2|^2 = \sum_{n,n'} c_n c_{n'} \left[a_n \tau_n a^*_{n'} \tau_{n'} + b_n \pi_n b^*_{n'} \pi_{n'} + a_n \tau_n b^*_{n'} \pi_{n'} + b_n \pi_n a^*_{n'} \tau_{n'} \right].$$

p. 105 π/τ orthogonality normalization.

Reads: $\displaystyle\int_0^\pi (\pi_n \pi_{n'} + \tau_n \tau_{n'}) \sin\theta \, d\theta = \frac{2n(n+1)^2}{2n+1} \quad (n = n').$

Should read: $\displaystyle\int_0^\pi (\pi_n \pi_{n'} + \tau_n \tau_{n'}) \sin\theta \, d\theta = \frac{2n^2(n+1)^2}{2n+1} \quad (n = n').$

p. 106 Rayleigh (small-sphere) scattering coefficients, overall sign.

Reads:

$$a_1 = -\frac{2i}{3}(ka)^3 \frac{\epsilon_d - \epsilon}{\epsilon_d + 2\epsilon}, \qquad b_1 = -\frac{2i}{3}(ka)^3 \frac{\mu_d - \mu}{\mu_d + 2\mu}.$$

Should read:

$$a_1 = +\frac{2i}{3}(ka)^3 \frac{\epsilon_d - \epsilon}{\epsilon_d + 2\epsilon}, \qquad b_1 = +\frac{2i}{3}(ka)^3 \frac{\mu_d - \mu}{\mu_d + 2\mu}.$$

p. 106 PEC-sphere Mie coefficients.

Reads:

$$a_n = -\frac{\hat{j}_n'(ka)}{\hat{h}_n^{(2)\prime}(ka)}, \qquad b_n = -\frac{\hat{j}_n(ka)}{\hat{h}_n^{(2)}(ka)}.$$

Should read:

$$a_n = +\frac{\hat{j}_n'(ka)}{\hat{h}_n^{(2)\prime}(ka)}, \qquad b_n = +\frac{\hat{j}_n(ka)}{\hat{h}_n^{(2)}(ka)}.$$

Chapter 5 — Special relativity

p. 111 derivation of the Lorentz transformation.

Reads: "Since by **(P2)** it is required that the transformation is linear …" *Should read:* "Since by **(P1)** it is required that the transformation is linear …"

p. 117 skew-tensor square identity.

Reads:

$$(\vec{\beta})^2 \cdot \vec{u} = \vec{\beta} \times (\vec{\beta} \times \vec{u}) = \vec{\beta}\vec{\beta} \cdot \vec{u} - \beta^2 \vec{u}.$$

Should read:

$$\bar{\bar{\beta}}^2 \cdot \vec{u} = \bar{\bar{\beta}} \cdot (\bar{\bar{\beta}} \cdot \vec{u}) = \vec{\beta} \times (\vec{\beta} \times \vec{u}) = \vec{\beta}\vec{\beta} \cdot \vec{u} - \beta^2 \vec{u}.$$

p. 118 identity used in deriving $c\vec{B}'$.

Reads:

$$\vec{\beta}\cdot[(\bar{\bar{\alpha}}\cdot\vec{\nabla}')\times\vec{E}] = \vec{\beta}\cdot\left[\left(\vec{\nabla}' + (\gamma-1)\frac{\vec{\beta}\cdot\vec{\nabla}'}{\beta^2}\vec{\beta}\right)\times\vec{E}\right]$$
$$= \beta\cdot(\vec{\nabla}'\times\vec{E}) = -\vec{\nabla}'\cdot(\vec{\beta}\times\vec{E}).$$

Should read:

$$\vec{\beta}\cdot[(\bar{\bar{\alpha}}\cdot\vec{\nabla}')\times\vec{E}] = \vec{\beta}\cdot\left[\left(\vec{\nabla}' + (\gamma-1)\frac{\vec{\beta}\cdot\vec{\nabla}'}{\beta^2}\vec{\beta}\right)\times\vec{E}\right]$$
$$= \vec{\beta}\cdot(\vec{\nabla}'\times\vec{E}) = -\vec{\nabla}'\cdot(\vec{\beta}\times\vec{E}).$$

Appendix B — Bessel and Hankel functions

p. 133 physical roles of the Hankel functions.

Reads: "… representing *outward and inward* cylindrical waves, respectively."
Should read: "… representing *inward and outward* cylindrical waves, respectively."

Appendix C — Legendre functions

p. 138 Legendre polynomial $P_5(x)$, missing factor of x.

Reads: $P_5(x) = \frac{1}{8}(63x^5 - 70x^3 + 15)$. *Should read:* $P_5(x) = \frac{1}{8}(63x^5 - 70x^3 + 15x)$.

p. 140 Legendre function of the second kind, closed form.

Reads:

$$Q_n(x) = \tfrac{1}{2}P_n(x)\ln\left(\frac{1+x}{1-x}\right) - \sum_{k=1}^{n}\frac{1\cdot3\cdot5\cdots(2k-1)}{2\cdot4\cdot6\cdots(2k)}\,P_{n-k}(x).$$

Should read:

$$Q_n(x) = \tfrac{1}{2}P_n(x)\ln\left(\frac{1+x}{1-x}\right) - \sum_{k=1}^{n}\frac{1}{k}\,P_{k-1}(x)\,P_{n-k}(x).$$