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Quantum Computing: From Alice to Bob

Corrections

Chapter 6

p. 67 In the paragraph after Eq. (6.24), the linear algebra terminology is wrong (it was accidentally copied from the previous section). The correct paragraph is

> If the inverse of a matrix A is equal to its inverse A^{-1}, then the matrix is said to be *involutory*. In that case, we have $A^{-1}A = AA = A^2 = I$. We can view A as a square root of identity matrix. It is easy to show that the Pauli operators X, Y, and Z are represented by involutory matrices.

p. 69. In the Chapter Summary, the Y matrix listed uses a sign convention different from elsewhere in the book. It should be $\mathrm{Y} \Rightarrow \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$.

Chapter 8

p. 91, the left side of the second equation in Try It 8.11 should have a down arrow, not an arrow to the left. The correct equation is

$$|\downarrow\rangle = \frac{1}{\sqrt{2}}|\rightarrow\rangle + \frac{1}{\sqrt{2}}|\leftarrow\rangle \tag{8.27}$$

Chapter 9

p. 113 In Try It 9.2, "column 3" should be "column 4."

p. 114 In the line after Eq. (9.6), "we us" should be "we use"

pp. 119-120 The arguments about Alice's and Bob's probabilities were not as clear as we would have liked. Here is, we hope, a clearer version:

So far, those results look reasonable based on what we have seen for single-qubit states. Life gets more interesting if Alice makes her observation first. As an example, suppose Alice makes an observation of the spin orientation of her qubit and finds that it is spin-up. (This will happen with probability $|c|^2+|d|^2$ (the sum of the probabilities in rows one and two in Table 9.2). Alice will get spin down with probability $|e|^2+|f|^2$. Similarly, Bob will get spin-up with probability $|c|^2+|e|^2$ and spin-down with probability $|d|^2+|f|^2$. Note that both Alice's and Bob's probabilities sum to 1.

Now let's examine what happens if Alice makes her measurements first and observes, for example, spin-up. To see what happens, let's use the general two-qubit quantum state in Eq. (9.11) with Alice's parts pulled to the left and Bob's expressed inside curly braces:

$$|S\rangle=\underbrace{|\uparrow_A\rangle}_{\text{Alice's}}\otimes\underbrace{\left\{c|\uparrow_B\rangle+d|\downarrow_B\rangle\right\}}_{\text{Bob's state, given Alice's}}+\underbrace{|\downarrow_A\rangle}_{\text{Alice's}}\otimes\underbrace{\left\{e|\uparrow_B\rangle+f|\downarrow_B\rangle\right\}}_{\text{Bob's state, given Alice's}}$$

We want to keep Bob normalized (or at least his quantum state vectors normalized), so we divide the terms in curly braces by the norms of Bob's states and then multiply Alice's state vector by that length:

$$|S\rangle=\underbrace{\sqrt{|c|^2+|d|^2}\,|\uparrow_A\rangle}_{\text{Alice}}\otimes\underbrace{\left\{\frac{c|\uparrow_B\rangle+d|\downarrow_B\rangle}{\sqrt{|c|^2+|d|^2}}\right\}}_{\text{Bob}}+\underbrace{\sqrt{|e|^2+|f|^2}\,|\downarrow_A\rangle}_{\text{Alice}}\otimes\underbrace{\left\{\frac{e|\uparrow_B\rangle+f|\downarrow_B\rangle}{\sqrt{|e|^2+|f|^2}}\right\}}_{\text{Bob}}. \qquad (9.1)$$

Eq. (9.1) tell us that when Alice has an observation of spin-up, Bob will get spin-up with probability $|c|^2/\left(|c|^2+|d|^2\right)$ and spin-down with probability $|d|^2/\left(|c|^2+|d|^2\right)$. (As always, the probabilities are given by the *squares* of Bob's state vector coefficients.) Note that Bob's probabilities add to 1. Eq. (9.1) is a fairly complicated expression but it will be a key element in quantum computation.

Try It 9.8 Write out Eq. (9.1) by hand and explain to yourself or a friend what the various terms mean. If Alice has an observation of spin-down, what is the probability of Bob's observing spin-up? Of Bob's observing spin-down? Explain your reasoning.

The conclusion is that Bob's probabilities depend on whether Alice observed spin-up or whether she observed spin-down. Bob's results are correlated with Alice's observation. Einstein called this “spooky action at a distance.” A somewhat less flamboyant statement would be “there is a correlation between Alice’s observation and Bob’s probabilities.” Note that if we ask for Bob’s probabilities (as we did in the paragraph after Table 9.3) when Alice does not make an observation, we see that they are different from Bob’s probabilities when she does. The latter case is one of so-called conditional probabilities (*if* Alice observes this, *then* Bob’s probabilities are…). The first case involves summing over Alice’s two possibilities. It should not be surprising that the results are different.

p. 124 In Try It 9.16, “Table 2” should be replaced by “Table 3”

p. 127 In Try It 9.20, item c., the text should read “…arguments in sections 9.5 and 9.6…”

p. 129 Just before Try It 9.21, the text should read “….(see Try It 9.21).”

Chapter 10

p. 138 Eq. (10.6) should be $\left|S_{out}\right\rangle = \frac{1}{\sqrt{2}}\left|0_A\right\rangle\left|0_B\right\rangle + \frac{1}{\sqrt{2}}\left|1_A\right\rangle\left|1_B\right\rangle$

p. 143 The un-numbered equation before Try It 10.7 should read

$$\mathrm{H}\left\{\frac{1}{\sqrt{2}}\left|00\right\rangle + \frac{1}{\sqrt{2}}\left|10\right\rangle\right\} = \frac{1}{2}\left(\left|00\right\rangle + \left|01\right\rangle + \left|00\right\rangle - \left|01\right\rangle\right) = \left|00\right\rangle = \left|0\right\rangle\left|0\right\rangle$$

p. 143 In Try It 10.7, first line should read “…states in Try It 10.5.”

p. 147 The C in Eq. (10.27) should not be italics. It should read

$$\mathrm{C}\left\{\left|A_0\right\rangle\left|0\right\rangle\right\} = \left|A_0\right\rangle\left|A_0\right\rangle$$

p. 148 Similarly, the Cs in Eq. (10.28)-(10.31) should not be italics.

p.148 The third line after Eq. (10.29) should not be indented.

p.150 In Eqs. (10.34) and (10.36) H_i should be H_C

p.151 Try It 10.11. The text should read “...any two-qubit Bell state, not just the Bell_{00} state. See the Chapter 10 Try It Solutions for details.

p. 154 H in Eqs. (10.41) and (10.42) should not be italicized.

p. 155 Line 5 of Step 5 should read “Alice’s measurement results…”

p. 155 The third entry in the third column of Table 10.3 should be $b\left|0\right\rangle - a\left|1\right\rangle$.

Chapter 12

p. 186 Try It 12.3 says “draw a diagram like the one below” and there is no diagram below

p. 192 The text in the last paragraph and the labeling in Fig. 12.8 may be confusing. See the Chapter 12 Try It 12.8 solution for better notation and clarifying remarks.

p. 205 Try It 12.15. “Figure 12.14” should be “Figure 12.18.”

Chapter 14

p. 246 Try It 14.1 The text should read “Fill in the bottom row of Table 14.1…”

Chapter 15

p. 282 Eq. (15.57) should read $U|\lambda\rangle = e^{i2\pi\alpha}|\lambda\rangle$, where α is a real number parameter and $|\lambda\rangle$ is the eigenstate associated with the eigenvalue λ of the operator *U*. In other words, the eigenvalues of unitary matrices have the property $|\lambda|^2 = 1$.