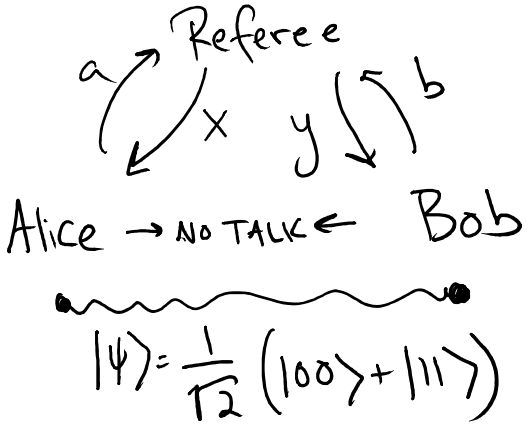
S. KIMMEL

Goals

- Calculate 2-qubit measurement outcomes
- Describe quantum gates
- Analyze bomb detection

(away next Thurs)

CHSH



Winning Condition:

$$x \wedge y = a \oplus b$$

Can enforce no communication using speed of light.

$$M(\theta) = \{\cos\theta|0\rangle + \sin\theta|1\rangle,\ -\sin\theta|0\rangle + \cos\theta|1\rangle\}$$

$|\phi_0(\theta)\rangle$ $\qquad$ $|\phi_1(\theta)\rangle$

x	Alice Measures
0	$M(0) = \{|0\rangle, |1\rangle\}$
1	$M(\frac{\pi}{4}) = \{|+\rangle, |-\rangle\}$

y	Bob Measures
0	$M(\pi/8)$
1	$M(-\pi/8)$

Outcome $|\phi_0(\theta)\rangle \rightarrow$ Respond "0"

Outcome $|\phi_1(\theta)\rangle \rightarrow$ Respond "1"

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Case 1

$x=y=0 \qquad x \wedge y = 0 \rightarrow a \oplus b = 0$

$a=b=0 \qquad a=b=1$

$$M = \{ |\phi_0(0)\rangle|\phi_0(\tfrac{\pi}{8})\rangle, |\phi_0(0)\rangle|\phi_1(\tfrac{\pi}{8})\rangle, |\phi_1(0)\rangle|\phi_0(\tfrac{\pi}{8})\rangle, |\phi_1(0)\rangle|\phi_1(\tfrac{\pi}{8})\rangle \}$$

Good outcomes
$(a=b=0)$
$(a=b=1)$

$P(a=b=0)$

$$= \left| \langle\phi_0(0)|_A \langle\phi_0(\tfrac{\pi}{8})|_B \tfrac{1}{\sqrt{2}}|00\rangle_{AB} + \tfrac{1}{\sqrt{2}}|11\rangle_{AB} \right|^2$$

$$= \left| \tfrac{1}{\sqrt{2}} \langle\phi_0(0)|0\rangle \langle\phi_0(\tfrac{\pi}{8})|0\rangle + \tfrac{1}{\sqrt{2}} \langle\phi_0(0)|1\rangle \langle\phi_0(\tfrac{\pi}{8})|1\rangle \right|^2$$

($\langle\phi_0(0)|0\rangle = 1$, $\langle\phi_0(0)|1\rangle = 0$)

$$= \left| \tfrac{1}{\sqrt{2}} \cos(\tfrac{\pi}{8}) \right|^2$$

$P(a=b=1)$

$$= \left| \tfrac{1}{\sqrt{2}} \langle\phi_1(0)|0\rangle \langle\phi_1(\tfrac{\pi}{8})|0\rangle + \tfrac{1}{\sqrt{2}} \langle\phi_1(0)|1\rangle \langle\phi_1(\tfrac{\pi}{8})|1\rangle \right|^2$$

($\langle\phi_1(0)|0\rangle = 0$, $\langle\phi_1(0)|1\rangle = 1$)

$$= \left| \tfrac{1}{\sqrt{2}} \cos(\tfrac{\pi}{8}) \right|^2$$

Total $\frac{1}{2}\cos^2(\frac{\pi}{8}) + \frac{1}{2}\cos^2(\frac{\pi}{8}) = \cos^2(\frac{\pi}{8}) = .85$

Get same for any value of x, y! Beats .75!