

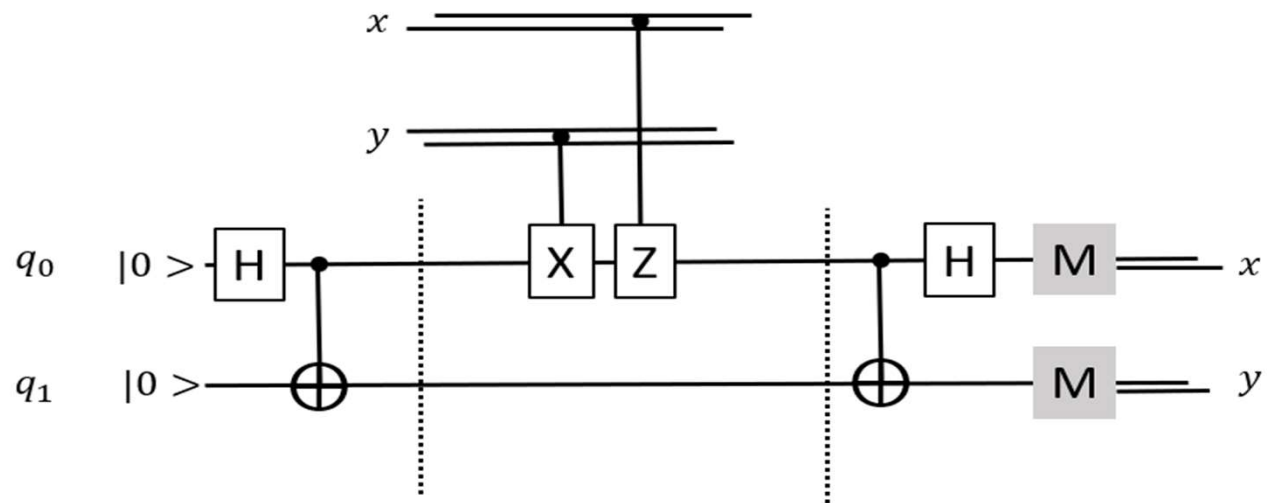
Einführung

Quantum Computing

HSK 13.11.2024

- **Dichte Kodierung**
- **CSHS Game**

Dichte Kodierung



Dichte Kodierung

xy	CX/CZ	Bell Messung
00	$\frac{1}{\sqrt{2}}(00\rangle + 11\rangle)$	00
01	$\frac{1}{\sqrt{2}}(10\rangle + 01\rangle)$	01
10	$\frac{1}{\sqrt{2}}(00\rangle - 11\rangle)$	10
11	$\frac{1}{\sqrt{2}}(- 10\rangle + 01\rangle)$	11

$1 \text{ qBit} \Leftrightarrow 2 \text{ klassische Bit}$

CHSH Game

$$x, y, a, b \in \{0,1\}$$

$$x, y: \quad p(0,0) = p(0,1) = p(1,0) = p(1,1)$$

$$\text{win:} \quad a \oplus b = x \wedge y$$

CHSH Game

$$a = f_a(x)$$

$$b = f_b(y)$$

x		f_1	f_2	f_3	f_4
0		0	0	1	1
1		0	1	0	1

CHSH Game

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

xy	win
00	$a = b$
01	$a = b$
10	$a = b$
11	$a \neq b$

CHSH Game

$$U(\theta, \phi, \lambda) = \begin{pmatrix} \cos\left(\frac{\theta}{2}\right) & -e^{i\lambda} \sin\left(\frac{\theta}{2}\right) \\ e^{i\phi} \sin\left(\frac{\theta}{2}\right) & e^{i(\phi+\lambda)} \cos\left(\frac{\theta}{2}\right) \end{pmatrix}$$

$$R_y(\theta) = \begin{pmatrix} \cos(\theta/2) & -\sin(\theta/2) \\ \sin(\theta/2) & \cos(\theta/2) \end{pmatrix} = u(\theta, 0, 0)$$

Alice:

U_0 für $x=0$

$U_{\pi/4}$ für $x=1$

Bob:

$U_{\pi/8}$ für $y=0$

$U_{-\pi/8}$ für $y=1$

CHSH Game

$$R_y(\theta) = \begin{pmatrix} \cos(\theta/2) & -\sin(\theta/2) \\ \sin(\theta/2) & \cos(\theta/2) \end{pmatrix} = u(\theta, 0, 0)$$

$$U_0 = \begin{pmatrix} \cos 0 & -\sin 0 \\ \sin 0 & \cos 0 \end{pmatrix}$$

$$U_{\pi/4} = \begin{pmatrix} \cos \pi/8 & -\sin \pi/8 \\ \sin \pi/8 & \cos \pi/8 \end{pmatrix}$$

$$U_{\pi/8} = \begin{pmatrix} \cos \pi/16 & -\sin \pi/16 \\ \sin \pi/16 & \cos \pi/16 \end{pmatrix}$$

$$U_{-\pi/8} = \begin{pmatrix} \cos^{-\pi/16} & -\sin^{-\pi/16} \\ \sin^{-\pi/16} & \cos^{-\pi/16} \end{pmatrix}$$

CHSH Game

x=0

y=0

$$\left(U_0 \otimes U_{\pi/8} \right) \left| \phi^+ \right\rangle = \frac{1}{\sqrt{2}} (\alpha |00\rangle + \beta |01\rangle + \gamma |10\rangle + \delta |11\rangle)$$

$$\alpha = \cos\left(\frac{-\pi}{8}\right) \quad \beta = \cos\left(\frac{-5\pi}{8}\right) \quad \gamma = \cos\left(\frac{3\pi}{8}\right) \quad \delta = \cos\left(\frac{-\pi}{8}\right)$$

CHSH Game

ab	p	p
00	$\alpha^2 = \frac{2 + \sqrt{2}}{8}$	0.42
01	$\beta^2 = \frac{2 - \sqrt{2}}{8}$	0.07
10	$\gamma^2 = \frac{2 - \sqrt{2}}{8}$	0.07
11	$\delta^2 = \frac{2 + \sqrt{2}}{8}$	0.42