Описание на паметта на квантов компютър

Припомняне: две употреби на бра-кет означенията:

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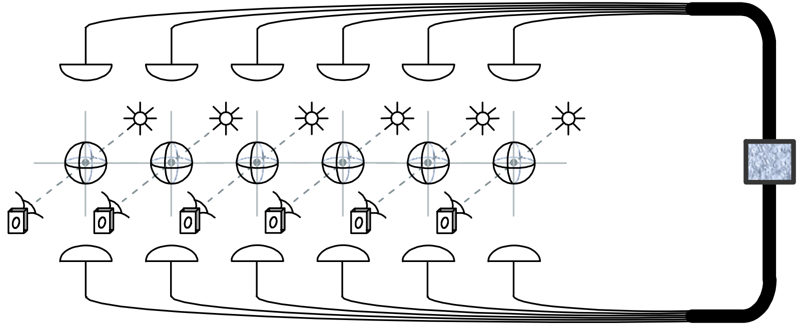
Сега обаче $|0\rangle \equiv e_0 \neq 0$ - нулевия вектор в $\mathbb{C}^N$!!!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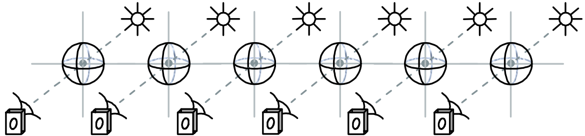
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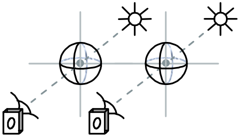
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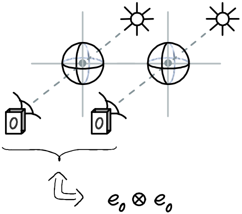
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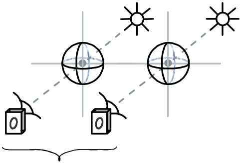
$e_0 \otimes e_0$

$$e_0 \otimes e_0 \equiv |e_0\rangle \otimes |e_0\rangle$$



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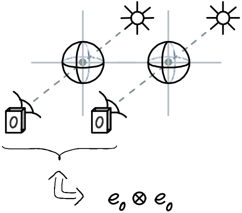
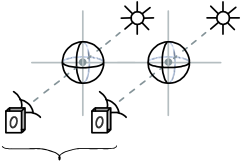


$$e_0 \otimes e_0 \equiv |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \boxed{\equiv |0\rangle|0\rangle \equiv |0,0\rangle}$$

нови означения



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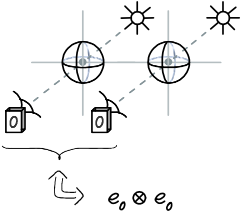
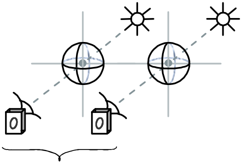


$$\underbrace{e_0 \otimes e_0} \equiv |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \equiv |0\rangle|0\rangle \equiv |0,0\rangle$$

$$\equiv$$

$$\overbrace{\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}}$$



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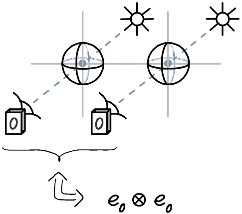
$$\equiv$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$



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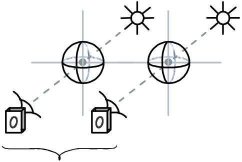

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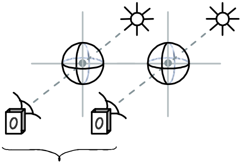

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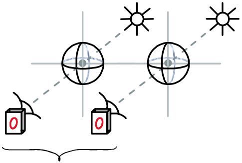

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$$\underbrace{e_0 \otimes e_0}_{\displaystyle \equiv} \equiv |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \equiv |0\rangle|0\rangle \equiv |0,0\rangle \equiv |\underbrace{[00]_2}_{\text{числото ``0'' в двоична система}}\rangle \equiv |0\rangle$$

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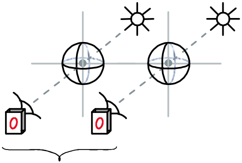

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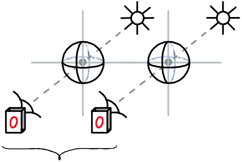

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има различен смисъл !!!

$$\equiv$$

$$\overbrace{\underbrace{\begin{pmatrix}1\\0\end{pmatrix}}_{e_0 \in \mathbb{C}^2} \otimes \begin{pmatrix}1\\0\end{pmatrix}} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix} \equiv e_0 \in \{e_0, e_1, e_2, e_3\}$$ – стандартния о.н.б. в $\mathbb{C}^4$

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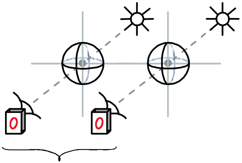

$e_0 \otimes e_0$

$$e_0^{(2)} \otimes e_0^{(2)} \equiv |e_0^{(2)}\rangle \otimes |e_0^{(2)}\rangle \equiv |0\rangle \otimes |0\rangle \equiv |0\rangle|0\rangle \equiv |0,0\rangle \equiv |\underbrace{[00]_2}_{\text{числото "0" в двоична система}}\rangle \equiv |0\rangle \leftarrow \left\{ \begin{array}{l} \text{има} \\ \text{различен смисъл !!!} \end{array} \right.$$

$$\underbrace{e_0^{(2)} \otimes e_0^{(2)}}_{\equiv}$$

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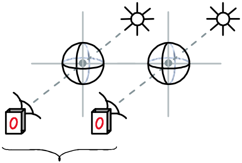
различен смисъл !!!



$$e_0^{(2)} \otimes e_0^{(2)}$$

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$$\equiv$$

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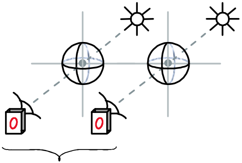

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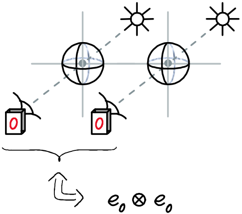
числото "0" в двоична система

$$\equiv$$

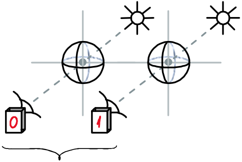
$$\overbrace{\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix} \equiv e_0 \in \{e_0, e_1, e_2, e_3\}$$ – стандартния о.н.б. в $\mathbb{C}^4$



$e_0 \otimes e_0$

$$\underbrace{e_0 \otimes e_1}_{\equiv} \equiv |e_0\rangle \otimes |e_1\rangle \equiv |0\rangle \otimes |1\rangle \equiv |0\rangle|1\rangle \equiv |0,1\rangle \equiv |\underbrace{[01]_2}_{\text{числото "1" в двоична система}}\rangle \equiv |1\rangle$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix} = \begin{pmatrix}0\\1\\0\\0\end{pmatrix} \equiv e_1 \in \{e_0, e_1, e_2, e_3\} \text{ – стандартния о.н.б. в } \mathbb{C}^4$$



$e_0 \otimes e_1$

$$e_0 \otimes e_1 \equiv |e_0\rangle \otimes |e_1\rangle \equiv |0\rangle \otimes |1\rangle \equiv |0\rangle|1\rangle \equiv |0,1\rangle \equiv |\underbrace{[01]_2}_{\text{числото „1" в двоична система}}\rangle \equiv |{\color{red}1}\rangle \leftarrow \left\{\begin{array}{l}\text{има}\\ \text{различен смисъл !!!}\end{array}\right.$$

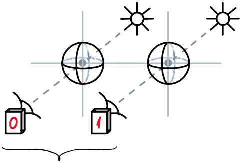
$$\underbrace{e_0 \otimes e_1}$$

$$\equiv$$

$$\overbrace{\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix}} = \begin{pmatrix}{\color{red}0}\\{\color{red}1}\\{\color{red}0}\\{\color{red}0}\end{pmatrix} \equiv {\color{red}e_1} \in \{e_0, {\color{red}e_1}, e_2, e_3\} \text{ – стандартния о.н.б. в } \mathbb{C}^4$$

$$\underbrace{\begin{pmatrix}1\\0\end{pmatrix}}_{e_0}, \quad \underbrace{\begin{pmatrix}0\\1\end{pmatrix}}_{e_1} \in \mathbb{C}^2$$

имат
различен смисъл !!!



$e_0 \otimes e_1$

$$\underbrace{e_0^{(2)} \otimes e_1^{(2)}} \equiv |e_0^{(2)}\rangle \otimes |e_1^{(2)}\rangle \equiv |0\rangle \otimes |1\rangle \equiv |0\rangle|1\rangle \equiv |0,1\rangle \equiv |\underbrace{[01]_2}\rangle \equiv |1\rangle \leftarrow$$

{ има различен смисъл !!!

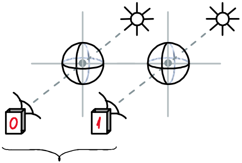
числото "1" в двоична система

$$\equiv$$

$$\overbrace{\underbrace{\begin{pmatrix}1\\0\end{pmatrix}} \otimes \underbrace{\begin{pmatrix}0\\1\end{pmatrix}}} = \begin{pmatrix}0\\1\\0\\0\end{pmatrix} \equiv e_1^{(4)} \in \{e_0^{(4)}, e_1^{(4)}, e_2^{(4)}, e_3^{(4)}\}$$ – стандартния о.н.б. в $\mathbb{C}^4$

$$e_0^{(2)},\ e_1^{(2)} \in \mathbb{C}^2$$

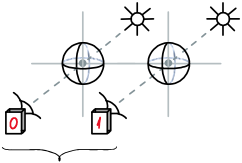
имат различен смисъл !!!



$$e_0^{(2)} \otimes e_1^{(2)}$$

$$\underbrace{e_0 \otimes e_1}_{\equiv} \equiv |e_0\rangle \otimes |e_1\rangle \equiv |0\rangle \otimes |1\rangle \equiv |0\rangle |1\rangle \equiv |0,1\rangle \equiv |\underbrace{[01]_2}_{\text{числото „1" в двоична система}}\rangle \equiv |1\rangle$$

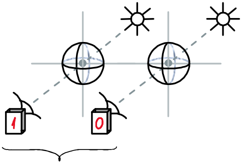
$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix} = \begin{pmatrix}0\\1\\0\\0\end{pmatrix} \equiv e_1 \in \{e_0, e_1, e_2, e_3\} \text{ – стандартния о.н.б. в } \mathbb{C}^4$$



$$e_0 \otimes e_1$$

$$\underbrace{e_1 \otimes e_0}_{\equiv} \equiv |e_1\rangle \otimes |e_0\rangle \equiv |1\rangle \otimes |0\rangle \equiv |1\rangle|0\rangle \equiv |1,0\rangle \equiv |\underbrace{[10]_2}_{\text{числото "2" в двоична система}}\rangle \equiv |2\rangle$$

$$\begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}0\\0\\1\\0\end{pmatrix} \equiv e_2 \in \{e_0, e_1, e_2, e_3\} \text{ - стандартния о.н.б. в } \mathbb{C}^4$$

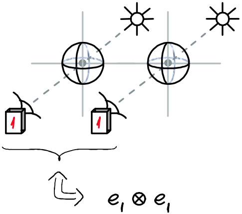


$e_1 \otimes e_0$

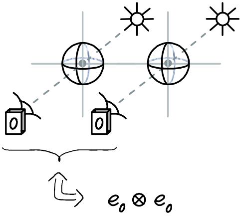
$$e_1 \otimes e_1 \equiv |e_1\rangle \otimes |e_1\rangle \equiv |1\rangle \otimes |1\rangle \equiv |1\rangle|1\rangle \equiv |1,1\rangle \equiv |\underbrace{[11]_2}_{\text{числото „3" в двоична система}}\rangle \equiv |3\rangle$$

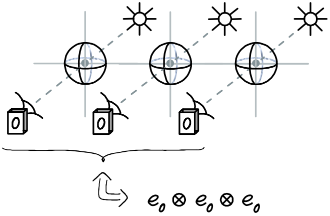
$$\equiv$$

$$\begin{pmatrix} 0 \\ 1 \end{pmatrix} \otimes \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1 \end{pmatrix} \equiv e_3 \in \{e_0, e_1, e_2, e_3\} \text{ – стандартния о.н.б. в } \mathbb{C}^4$$

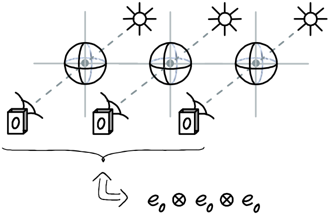


$e_1 \otimes e_1$




0
0
0
$e_0 \otimes e_0 \otimes e_0$

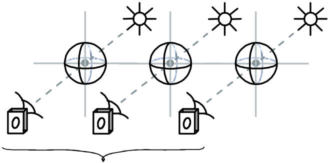
$$\underbrace{e_0 \otimes e_0 \otimes e_0}_{\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}}$$



$$e_0 \otimes e_0 \otimes e_0$$

$$\underbrace{e_0 \otimes \left(e_0 \otimes e_0\right)}$$

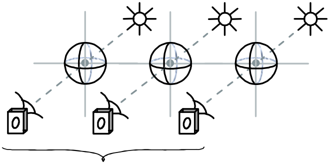
$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$



$$e_0 \otimes e_0 \otimes e_0$$

$$\underbrace{e_0 \otimes (e_0 \otimes e_0)}$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix} \right) = \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$

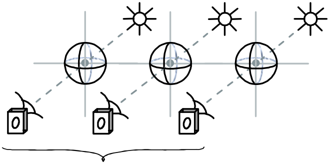


$$e_0 \otimes e_0 \otimes e_0$$

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$(e_0 \otimes (e_0) \otimes e_0)$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$



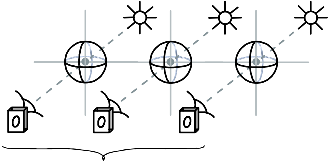
$$e_0 \otimes e_0 \otimes e_0$$

Описание на паметта на квантов компютър

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$(e_0 \otimes (e_0) \otimes e_0)$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$



$$e_0 \otimes e_0 \otimes e_0$$

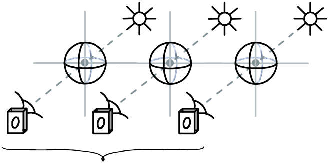
Описание на паметта на квантов компютър

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$\overbrace{\underbrace{(e_0\otimes(e_0)\otimes e_0)}}$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$

$$\begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix}$$

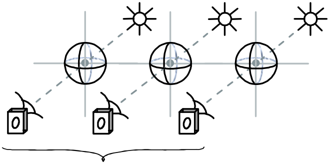


$$e_0\otimes e_0\otimes e_0$$

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$(e_0 \otimes (e_0) \otimes e_0) = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix}$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$



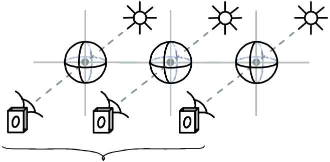
$$e_0 \otimes e_0 \otimes e_0$$

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$e_0\otimes e_0\otimes e_0 = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix}$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$

Тензорното произведение е асоциативно
(т.е., скобите могат да се местят)



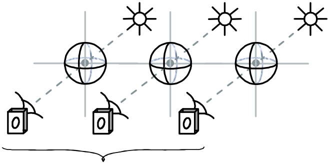
$$e_0\otimes e_0\otimes e_0$$

Описание на паметта на квантов компютър

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$\overbrace{\underbrace{(e_0 \otimes (e_0) \otimes e_0)}}\; = \longrightarrow \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix}$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$

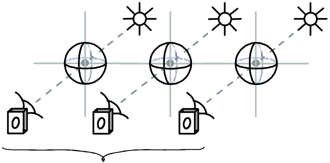


$$e_0 \otimes e_0 \otimes e_0$$

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$(e_0 \otimes (e_0) \otimes e_0) \Longrightarrow \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$



$$e_0 \otimes e_0 \otimes e_0$$

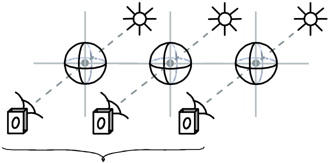
Описание на паметта на квантов компютър

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$(e_0 \otimes (e_0) \otimes e_0) = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$

– стандартния о.н.б. в $\mathbb{C}^8$



$$e_0 \otimes e_0 \otimes e_0$$

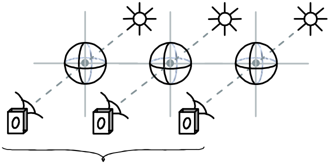
Описание на паметта на квантов компютър

$$\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right)\otimes\begin{pmatrix}1\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}$$

$$\left(e_0^{(2)}\otimes\left(e_0^{(2)}\right)\otimes e_0^{(2)}\right) = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\}$$

$$\begin{pmatrix}1\\0\end{pmatrix}\otimes\left(\begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\end{pmatrix}\right) = \begin{pmatrix}1\\0\end{pmatrix}\otimes\begin{pmatrix}1\\0\\0\\0\end{pmatrix}$$

– стандартния о.н.б. в $\mathbb{C}^8$

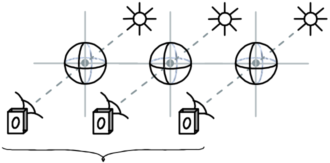


$$e_0^{(2)}\otimes e_0^{(2)}\otimes e_0^{(2)}$$

$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)}$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \left\{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\right\}$$ – стандартния о.н.б. в $\mathbb{C}^8$

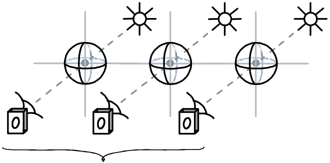


$$e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\}$$ – стандартния о.н.б. в $\mathbb{C}^8$

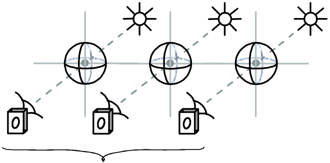


$$e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\begin{pmatrix} 1 \\ 0 \end{pmatrix} \otimes \left(\begin{pmatrix} 1 \\ 0 \end{pmatrix} \otimes \begin{pmatrix} 1 \\ 0 \end{pmatrix} \right)$$

$$= \begin{pmatrix} 1 \\ 0 \end{pmatrix} \otimes \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix} = e_0^{(8)} \in \{ e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)} \}$$ – стандартния о.н.б. в $\mathbb{C}^8$



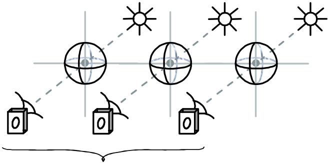
$$e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|0\rangle|0\rangle$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



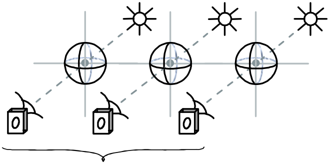
$$e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)}_{} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|0\rangle|0\rangle \equiv |0,0,0\rangle$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



$$e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

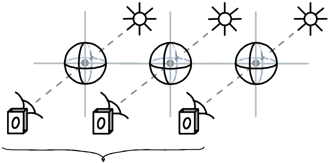
Описание на паметта на квантов компютър

$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|0\rangle|0\rangle \equiv |0,0,0\rangle \equiv |\underbrace{[000]_2}_{\text{числото "0" в двоична система}}\rangle$$

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\} \text{ – стандартния о.н.б. в } \mathbb{C}^8$$



$$\Leftrightarrow \quad e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

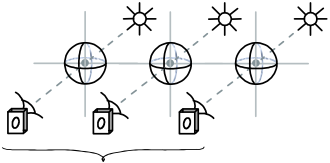
$$\underbrace{e_0^{(2)} \otimes \left(e_0^{(2)} \otimes e_0^{(2)}\right)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|0\rangle|0\rangle \equiv |0,0,0\rangle \equiv |\underbrace{[000]_2}\rangle \equiv |0\rangle$$

числото "0" в двоична система

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0^{(8)} \in \{e_0^{(8)}, e_1^{(8)}, e_2^{(8)}, e_3^{(8)}, e_4^{(8)}, e_5^{(8)}, e_6^{(8)}, e_7^{(8)}\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



$$e_0^{(2)} \otimes e_0^{(2)} \otimes e_0^{(2)}$$

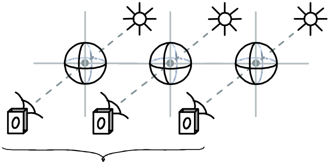
$$\underbrace{e_0 \otimes (e_0 \otimes e_0)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|0\rangle|0\rangle \equiv |0,0,0\rangle \equiv |[\underbrace{000}]_2\rangle \equiv |0\rangle$$

числото "0" в двоична система

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\} \text{ - стандартния о.н.б. в } \mathbb{C}^8$$



$$e_0 \otimes e_0 \otimes e_0$$

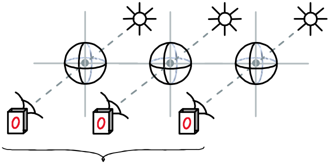
$$\underbrace{e_0 \otimes (e_0 \otimes e_0)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|0\rangle|0\rangle \equiv |0,0,0\rangle \equiv |\underbrace{[000]_2}\rangle \equiv |0\rangle$$

числото "0" в двоична система

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}1\\0\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_0 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



$$e_0 \otimes e_0 \otimes e_0$$

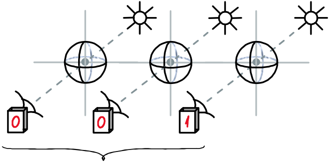
$$\underbrace{e_0 \otimes (e_0 \otimes e_1)} \equiv |e_0\rangle \otimes |e_0\rangle \otimes |e_1\rangle \equiv |0\rangle \otimes |0\rangle \otimes |1\rangle$$

$$\equiv |0\rangle|0\rangle|1\rangle \equiv |0,0,1\rangle \equiv |\underbrace{[001]_2}\rangle \equiv |1\rangle$$

числото "1" в двоична система

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\1\\0\\0\end{pmatrix} = \begin{pmatrix}0\\1\\0\\0\\0\\0\\0\\0\end{pmatrix} = e_1 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



$$e_0 \otimes e_0 \otimes e_1$$

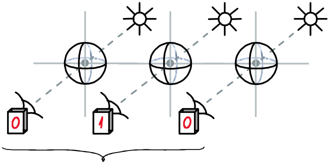
$$\underbrace{e_0 \otimes (e_1 \otimes e_0)}_{} \equiv |e_0\rangle \otimes |e_1\rangle \otimes |e_0\rangle \equiv |0\rangle \otimes |1\rangle \otimes |0\rangle$$

$$\equiv |0\rangle|1\rangle|0\rangle \equiv |0,1,0\rangle \equiv |\underbrace{[010]_2}_{}\rangle \equiv |2\rangle$$

числото "2" в двоична система

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\0\\1\\0\end{pmatrix} = \begin{pmatrix}0\\0\\1\\0\\0\\0\\0\\0\end{pmatrix} = e_2 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



$e_0 \otimes e_1 \otimes e_0$

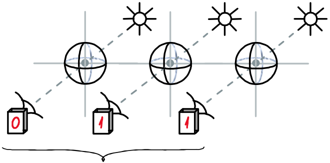
$$\underbrace{e_0 \otimes (e_1 \otimes e_1)} \equiv |e_0\rangle \otimes |e_1\rangle \otimes |e_1\rangle \equiv |0\rangle \otimes |1\rangle \otimes |1\rangle$$

$$\equiv |0\rangle|1\rangle|1\rangle \equiv |0,1,1\rangle \equiv |\underbrace{[011]}_2\rangle \equiv |3\rangle$$

числото "3" в двоична система

$$\begin{pmatrix}1\\0\end{pmatrix} \otimes \left(\begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix} \right)$$

$$= \begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\0\\0\\1\end{pmatrix} = \begin{pmatrix}0\\0\\0\\1\\0\\0\\0\\0\end{pmatrix} = e_3 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



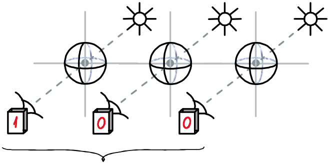
$e_0 \otimes e_1 \otimes e_1$

$$\underbrace{e_1 \otimes (e_0 \otimes e_0)} \equiv |e_1\rangle \otimes |e_0\rangle \otimes |e_0\rangle \equiv |1\rangle \otimes |0\rangle \otimes |0\rangle$$

$$\equiv |1\rangle|0\rangle|0\rangle \equiv |1,0,0\rangle \equiv |[\underbrace{100}_{\text{числото “4” в двоична система}}]_2\rangle \equiv |4\rangle$$

$$\begin{pmatrix}0\\1\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}1\\0\\0\\0\end{pmatrix} = \begin{pmatrix}0\\0\\0\\0\\1\\0\\0\\0\end{pmatrix} = e_4 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\} \text{ – стандартния о.н.б. в } \mathbb{C}^8$$



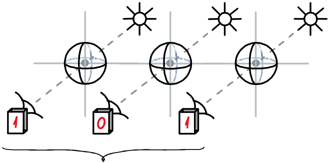
$$e_1 \otimes e_0 \otimes e_0$$

$$\underbrace{e_1 \otimes (e_0 \otimes e_1)} \equiv |e_1\rangle \otimes |e_0\rangle \otimes |e_1\rangle \equiv |1\rangle \otimes |0\rangle \otimes |1\rangle$$

$$\equiv |1\rangle|0\rangle|1\rangle \equiv |1,0,1\rangle \equiv |\underbrace{[101]_2}_{\text{числото “5” в двоична система}}\rangle \equiv |5\rangle$$

$$\begin{pmatrix}0\\1\end{pmatrix} \otimes \left(\begin{pmatrix}1\\0\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix}\right)$$

$$= \begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}0\\1\\0\\0\end{pmatrix} = \begin{pmatrix}0\\0\\0\\0\\0\\1\\0\\0\end{pmatrix} = e_5 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\} \text{ – стандартния о.н.б. в } \mathbb{C}^8$$



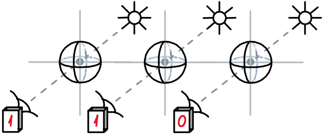
$e_1 \otimes e_0 \otimes e_1$

$$\underbrace{e_1 \otimes (e_1 \otimes e_0)} \equiv |e_1\rangle \otimes |e_1\rangle \otimes |e_0\rangle \equiv |1\rangle \otimes |1\rangle \otimes |0\rangle$$

$$\equiv |1\rangle|1\rangle|0\rangle \equiv |1,1,0\rangle \equiv |\underbrace{[110]_2}_{\text{числото "6" в двоична система}}\rangle \equiv |6\rangle$$

$$\begin{pmatrix}0\\1\end{pmatrix} \otimes \left(\begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}1\\0\end{pmatrix}\right)$$

$$= \begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}0\\0\\1\\0\end{pmatrix} = \begin{pmatrix}0\\0\\0\\0\\0\\0\\1\\0\end{pmatrix} = e_6 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\} \text{ – стандартния о.н.б. в } \mathbb{C}^8$$



$$\underbrace{\qquad\qquad\qquad}_{\hookrightarrow\ e_1 \otimes e_1 \otimes e_0}$$

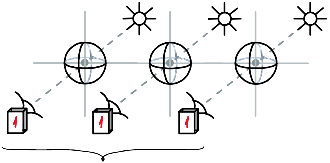
Описание на паметта на квантов компютър

$$\underbrace{e_1 \otimes (e_1 \otimes e_1)} \equiv |e_1\rangle \otimes |e_1\rangle \otimes |e_1\rangle \equiv |1\rangle \otimes |1\rangle \otimes |1\rangle$$

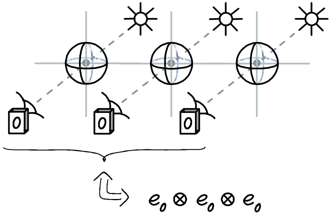
$$\equiv |1\rangle|1\rangle|1\rangle \equiv |1,1,1\rangle \equiv |\underbrace{[111]_2}_{\text{числото “7” в двоична система}}\rangle \equiv |7\rangle$$

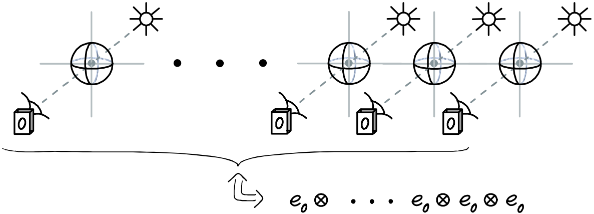
$$\begin{pmatrix}0\\1\end{pmatrix} \otimes \left(\begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}0\\1\end{pmatrix}\right)$$

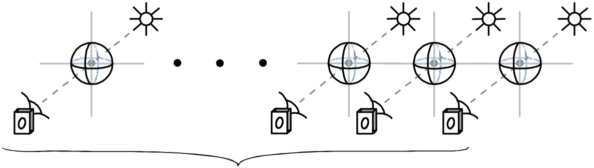
$$= \begin{pmatrix}0\\1\end{pmatrix} \otimes \begin{pmatrix}0\\0\\0\\1\end{pmatrix} = \begin{pmatrix}0\\0\\0\\0\\0\\0\\0\\1\end{pmatrix} = e_7 \in \{e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7\}$$ – стандартния о.н.б. в $\mathbb{C}^8$



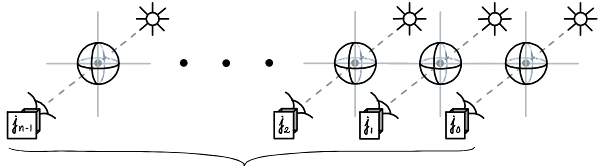
$$e_1 \otimes e_1 \otimes e_1$$


$e_0 \otimes e_0 \otimes e_0$

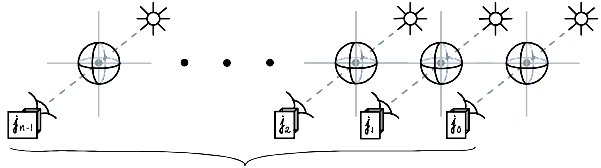

0
0
0
0
$e_0 \otimes \cdots e_0 \otimes e_0 \otimes e_0$



$$e_0 \otimes \cdots e_0 \otimes e_0 \otimes e_0 = |0\rangle \in \mathbb{C}^N$$



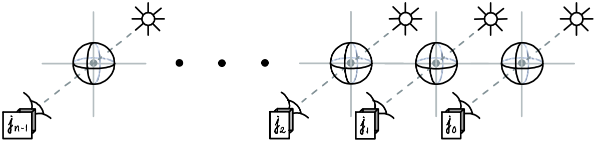
$$e_{j_{n-1}} \otimes \cdots e_{j_2} \otimes e_{j_1} \otimes e_{j_0} = |\ell\rangle \in \mathbb{C}^N$$



$$e_{j_{n-1}} \otimes \cdots e_{j_2} \otimes e_{j_1} \otimes e_{j_0} = |\ell\rangle \in \mathbb{C}^N$$

за $j_0, \dots, j_{n-1} = 0, 1$ и $N = 2^n$

$$\ell = [j_{n-1} \cdots j_1 j_0]_2 := j_{n-1}\, 2^{n-1} + \cdots + j_1\, 2^1 + j_0\, 2^0$$



където

$$e_{j_{n-1}} \otimes \cdots e_{j_2} \otimes e_{j_1} \otimes e_{j_0} = |\ell\rangle \in \mathbb{C}^N$$

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двоично разлагане

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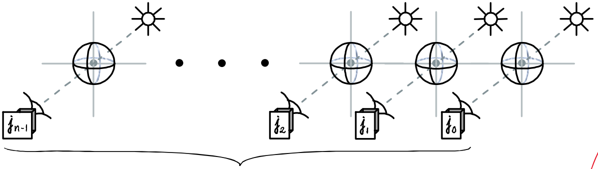

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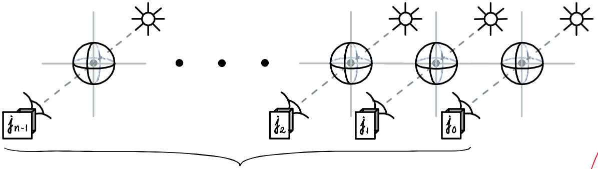
за $j_0, \dots, j_{n-1} = 0, 1$ и $N = 2^n$

двоично разлагане

$$\ell = [j_{n-1}\cdots j_1 j_0]_2 := j_{n-1}\,2^{n-1} + \cdots + j_1\,2^1 + j_0\,2^0 \in \{0,\dots,N-1\}$$



където

$$e_{j_{n-1}} \otimes \cdots e_{j_2} \otimes e_{j_1} \otimes e_{j_0} = |\ell\rangle \in \mathbb{C}^N$$

за $j_0,\dots,j_{n-1} = 0, 1$ и $N = 2^n$

Изводи:

Изводи: хилбертовото пространство на състоянията на система от n квантови бита (кубити) е $\mathbb{C}^N$ (N-мерно) за $N = 2^n$

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Стандартния базис $e_0 \equiv |0\rangle$ и $e_1 \equiv |1\rangle$ в $\mathbb{C}^2$ пораждат стандартния базис в $\mathbb{C}^N$: $|[j_{n-1} \cdots j_0]_2\rangle = e_{j_{n-1}} \otimes \cdots \otimes e_{j_0}$

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