Einführung in die Quantenrechnung
Bits und Qubits

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P&GG Monotechnische Anstalt

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Outline

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1. Einfache Computadoras
   - Mathematik
   - Architektur
2. Computadora Cuántica: Eine schwarze Kunst
   - Quantenzustände

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Binäre Zahlen

In decimal notation,

$$1572_{10} = 1 \times 10^3 +$$

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From binary to decimal,

$$\begin{aligned} 1001101_2 &= 1 \times 2^6 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^0 \\ &= 64 + 8 + 4 + 1 \\ &= 77_{10} \end{aligned}$$

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Going from decimal to binary notation,

$$\begin{aligned} 27_{10} &= 16 + 8 + 2 + 1 \\ &= 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \\ &= 11011_2 \end{aligned}$$

Powers von zwei

$$2^0 = 1 \qquad = 000000001_2$$
$$2^1 =$$
$$2^2 =$$
$$2^3 =$$
$$2^4 =$$
$$2^5 =$$
$$2^6 =$$
$$2^7 =$$
$$2^8 =$$

Powers von zwei

$$
\begin{aligned}
2^0 &= 1 && = 000000001_2 \\
2^1 &= 2 && = 000000010_2 \\
2^2 &= \\
2^3 &= \\
2^4 &= \\
2^5 &= \\
2^6 &= \\
2^7 &= \\
2^8 &=
\end{aligned}
$$

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2^4 &= \\
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2^3 &= 8 && = 000001000_2 \\
2^4 &= 16 && = 000010000_2 \\
2^5 &= 32 && = 000100000_2 \\
2^6 &= \\
2^7 &= \\
2^8 &=
\end{aligned}
$$

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2^0 &= 1 && = 000000001_2 \\
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2^2 &= 4 && = 000000100_2 \\
2^3 &= 8 && = 000001000_2 \\
2^4 &= 16 && = 000010000_2 \\
2^5 &= 32 && = 000100000_2 \\
2^6 &= 64 && = 001000000_2 \\
2^7 &= \\
2^8 &=
\end{aligned}
$$

Powers von zwei

$$
\begin{aligned}
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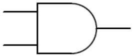
2^1 &= 2 && = 000000010_2 \\
2^2 &= 4 && = 000000100_2 \\
2^3 &= 8 && = 000001000_2 \\
2^4 &= 16 && = 000010000_2 \\
2^5 &= 32 && = 000100000_2 \\
2^6 &= 64 && = 001000000_2 \\
2^7 &= 128 && = 010000000_2 \\
2^8 &=
\end{aligned}
$$

Powers von zwei

$$
\begin{aligned}
2^0 &= 1 && = 000000001_2 \\
2^1 &= 2 && = 000000010_2 \\
2^2 &= 4 && = 000000100_2 \\
2^3 &= 8 && = 000001000_2 \\
2^4 &= 16 && = 000010000_2 \\
2^5 &= 32 && = 000100000_2 \\
2^6 &= 64 && = 001000000_2 \\
2^7 &= 128 && = 010000000_2 \\
2^8 &= 256 && = 100000000_2
\end{aligned}
$$

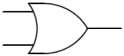
Outline

Logic Gates



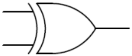
AND

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1



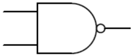
OR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1



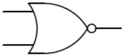
XOR

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0



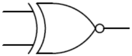
NAND

A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0



NOR

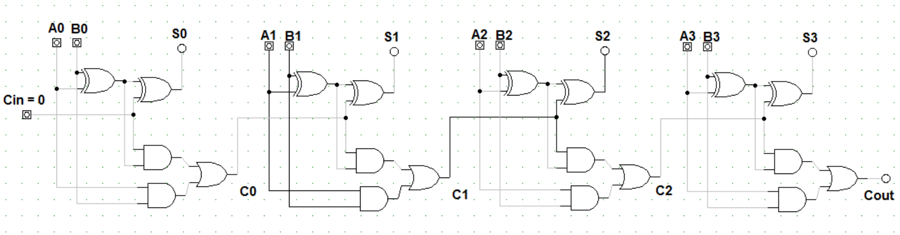
A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0



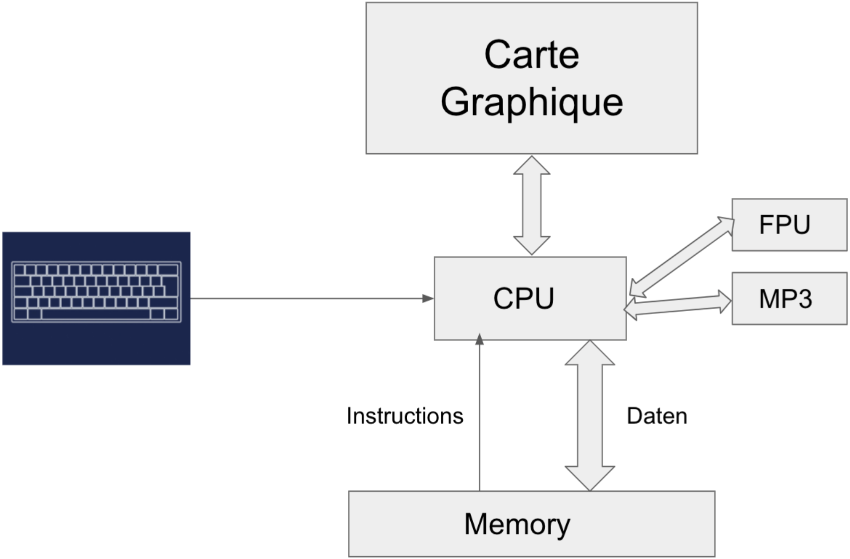
XNOR

A	B	Output
0	0	1
0	1	0
1	0	0
1	1	1

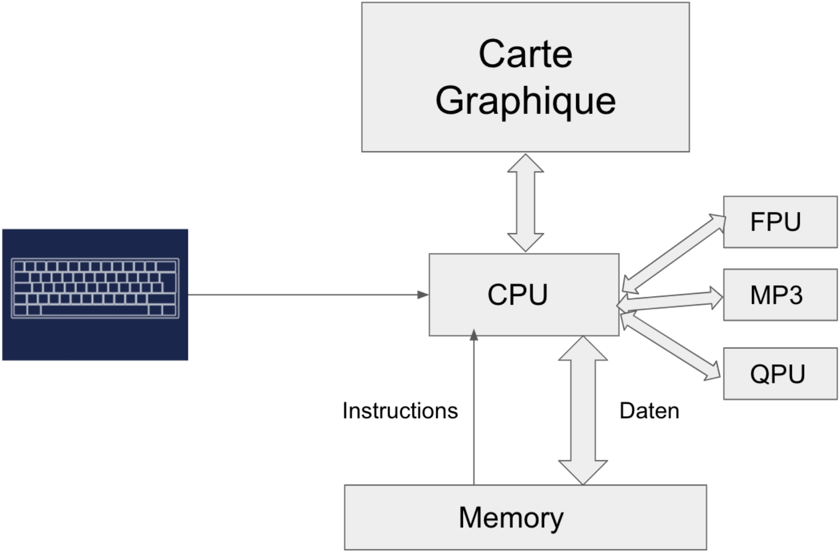
Adder



Computer Architektur



Computer Architektur



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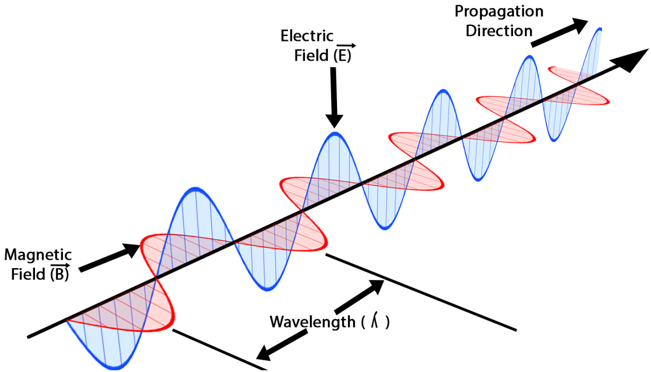
A QPU operates on Qubits instead of bits

- QPU: Quantum Processing Unit
- Bits: 0, 1
- Qubits: $|0\rangle$, $|1\rangle$, and superpositions

Light is a wave



Polarization Experiment

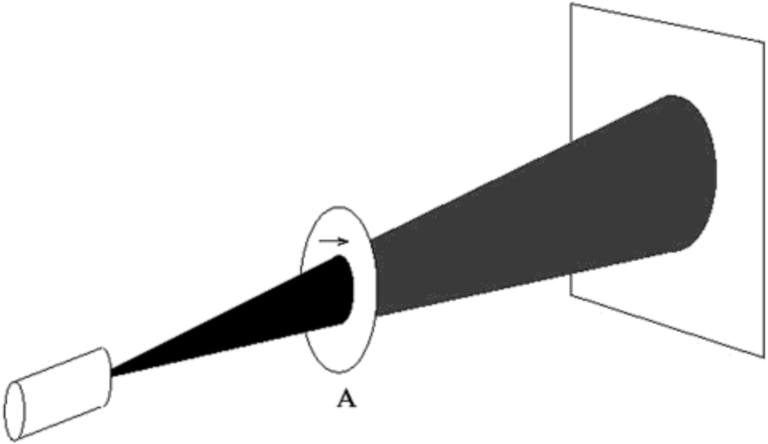


Figure 2.1
Single polaroid attenuates unpolarized light by 50 percent.

Polarization Experiment

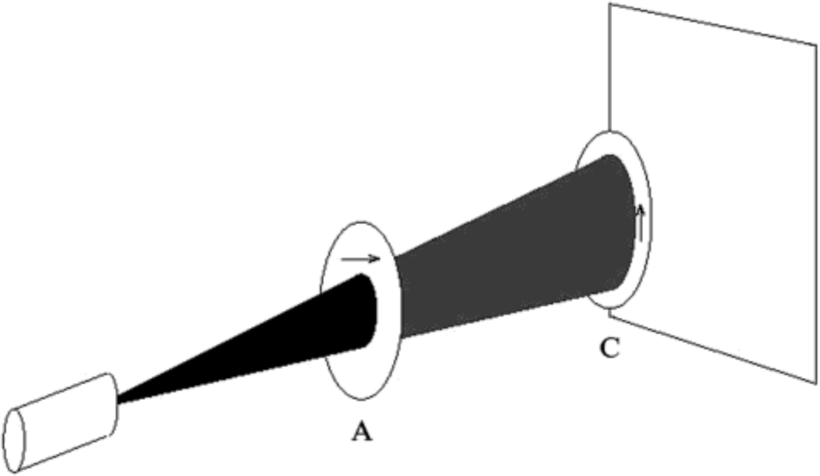


Figure 2.2
Two orthogonal polaroids block all photons.

Polarization Experiment

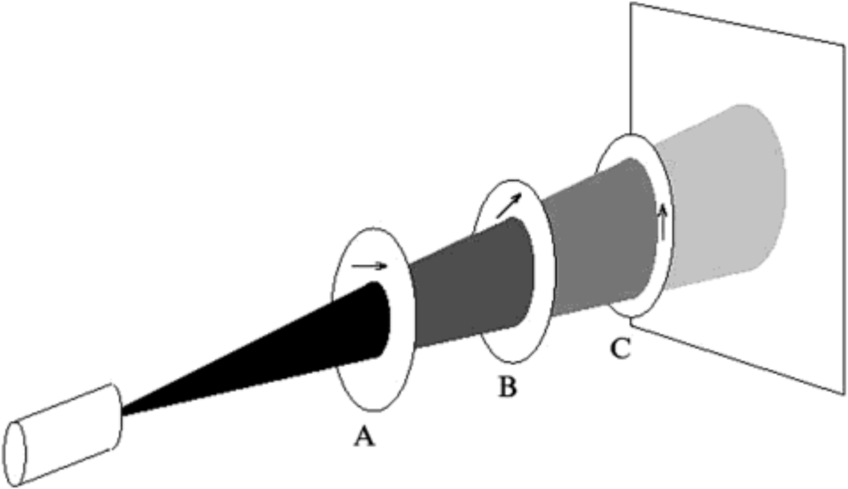


Figure 2.3
Inserting a third polaroid allows photons to pass.

Vektoren

Alle Polarisationsrichtungen können durch zwei Vektoren dargestellt werden:

$$|\psi\rangle = a\,|{\rightarrow}\rangle + b\,|{\uparrow}\rangle$$

Die Notation wird Bra-ket Notation genannt.
Beispiele:

$$\begin{aligned}
|45^\circ\rangle &= \frac{1}{\sqrt{2}}\,|{\rightarrow}\rangle + \frac{1}{\sqrt{2}}\,|{\uparrow}\rangle \\
|135^\circ\rangle &= -\frac{1}{\sqrt{2}}\,|{\rightarrow}\rangle + \frac{1}{\sqrt{2}}\,|{\uparrow}\rangle \\
|30^\circ\rangle &= \frac{1}{2}\,|{\rightarrow}\rangle + \frac{\sqrt{3}}{2}\,|{\uparrow}\rangle \\
|\theta\rangle &= \sin\theta\,|{\rightarrow}\rangle + \cos\theta\,|{\uparrow}\rangle
\end{aligned}$$

Wahrscheinlichkeiten