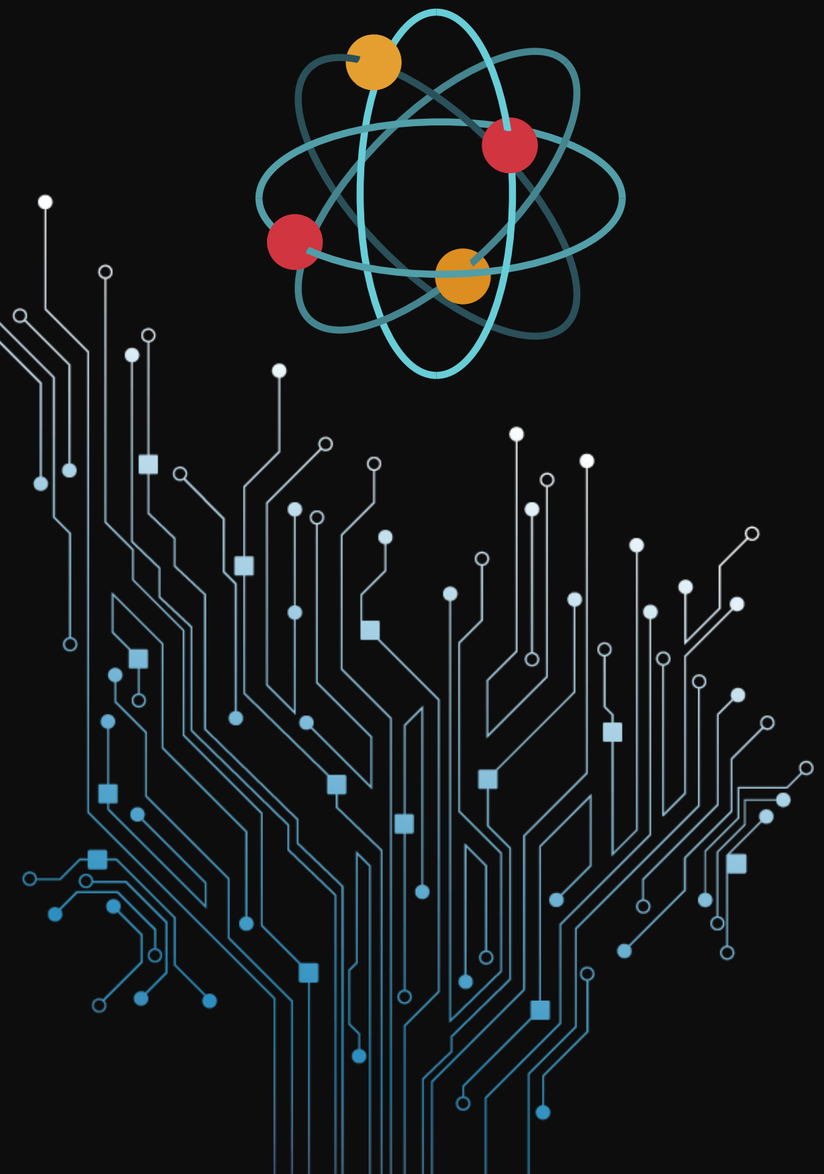
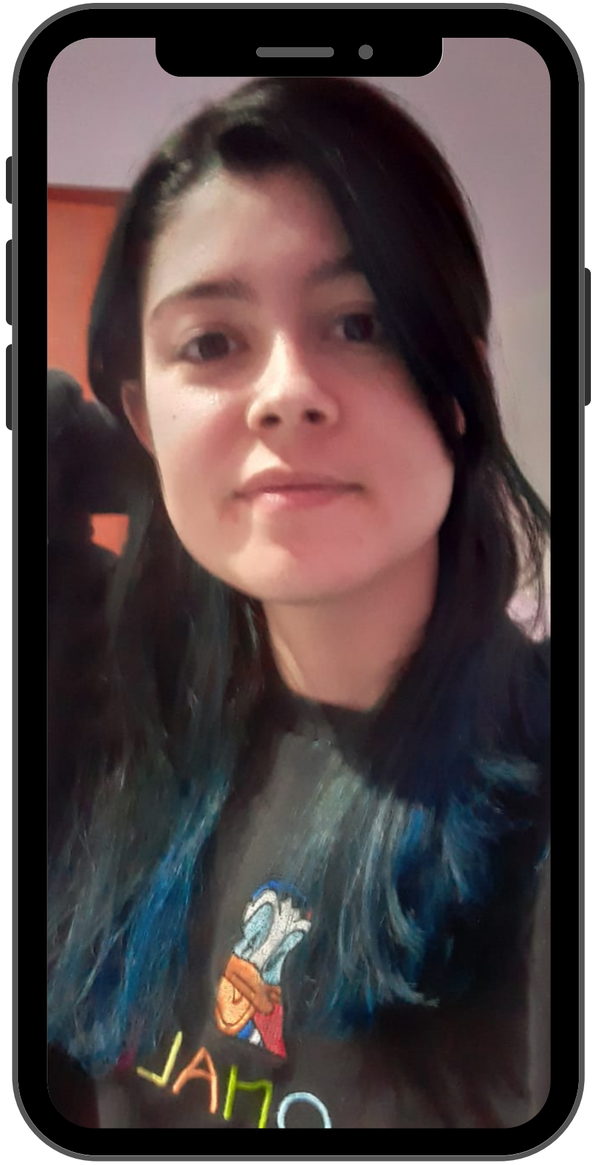


*Primeiros Passos na*

# COMPUTAÇÃO QUÂNTICA

Amanda G. Valério

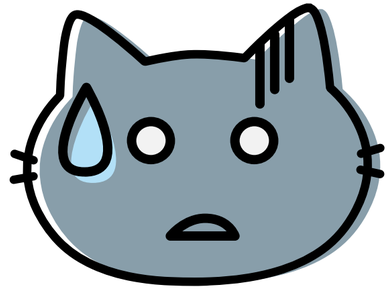



# Quem sou eu (ou como cheguei aqui)

- Aluna do 6° período de Ciência da Computação no IFSuldeMinas
- Iniciação Cientifica de 2019 à 2020 (um ano e meio) Análise e Comparação da Complexidade de Algoritmos de Busca utilizando os Paradigmas Clássico e Quântico - Valério, A.; Brant-Ribeiro, T. (2019)
- Membra co-fundadora do PyLadies Sul de MInas

CONTATO:

amanda.valerio@alunos.ifsuldeminas.edu.br



Mas o que é

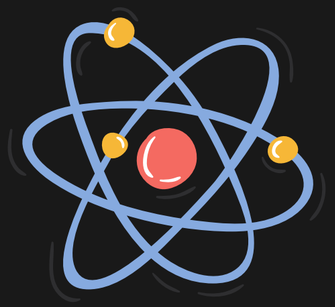
# COMPUTAÇÃO QUÂNTICA?

Mas o que é

# COMPUTAÇÃO QUÂNTICA?

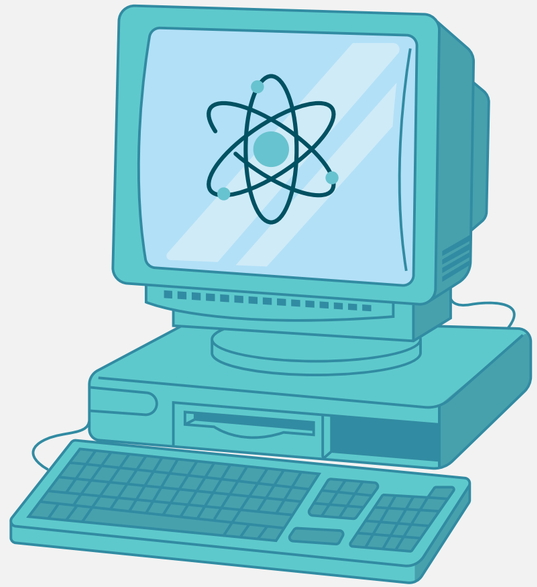
É um novo paradigma de computação que utiliza as propriedades da física quântica para aumentar a velocidade de processamento

# E DE ONDE SURGIU?



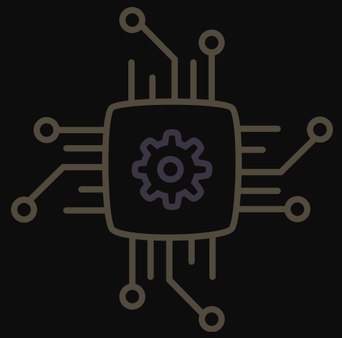
# Um Breve Resumo

- Surgimento da Mecânica Quântica
- Simulação de experimentos
- Lei de Moore
- Ausência de tecnologia suficiente na época
- Interferência nos processadores atuais
- "Corrida" pela supremacia



Vamos entender um pouco melhor tudo isso

Começando pelos **QUBITS**

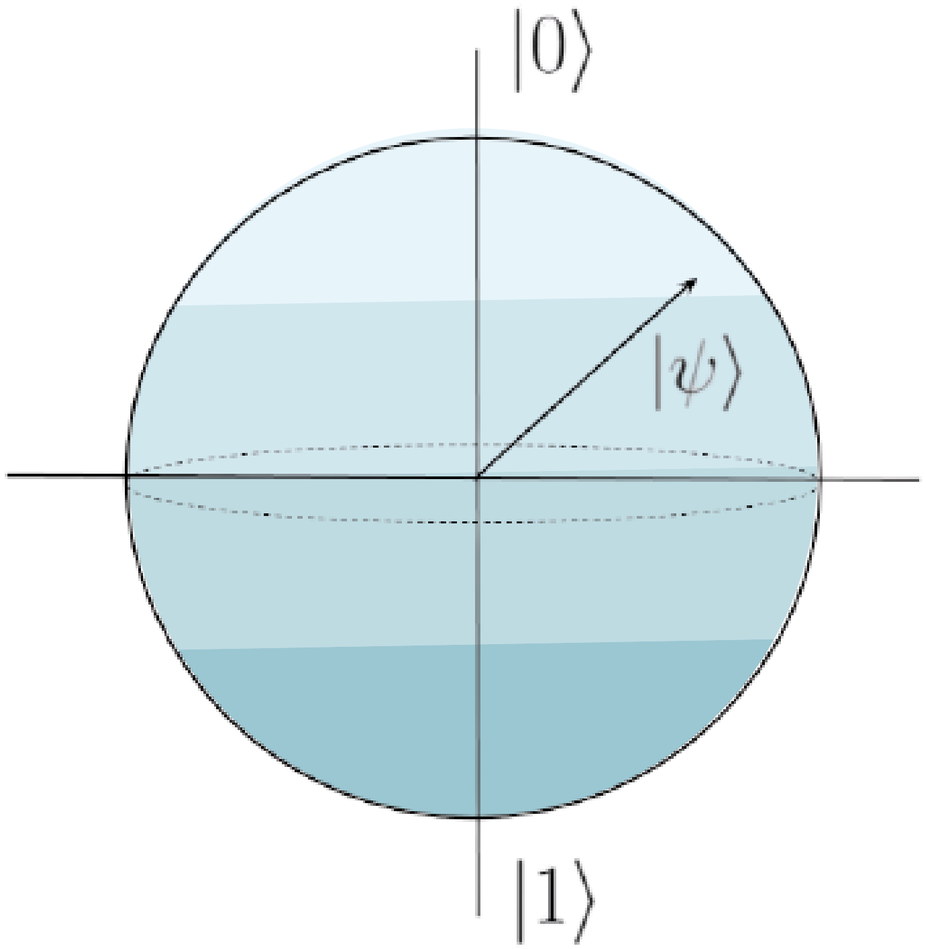


# Bit x QuBit

- Pulsos de frequências elétricas
- Valor: 0 ou 1
- Propriedades clássicas

- Partículas
- Probabilidade de estados
- 0 e 1
- Propriedades quânticas

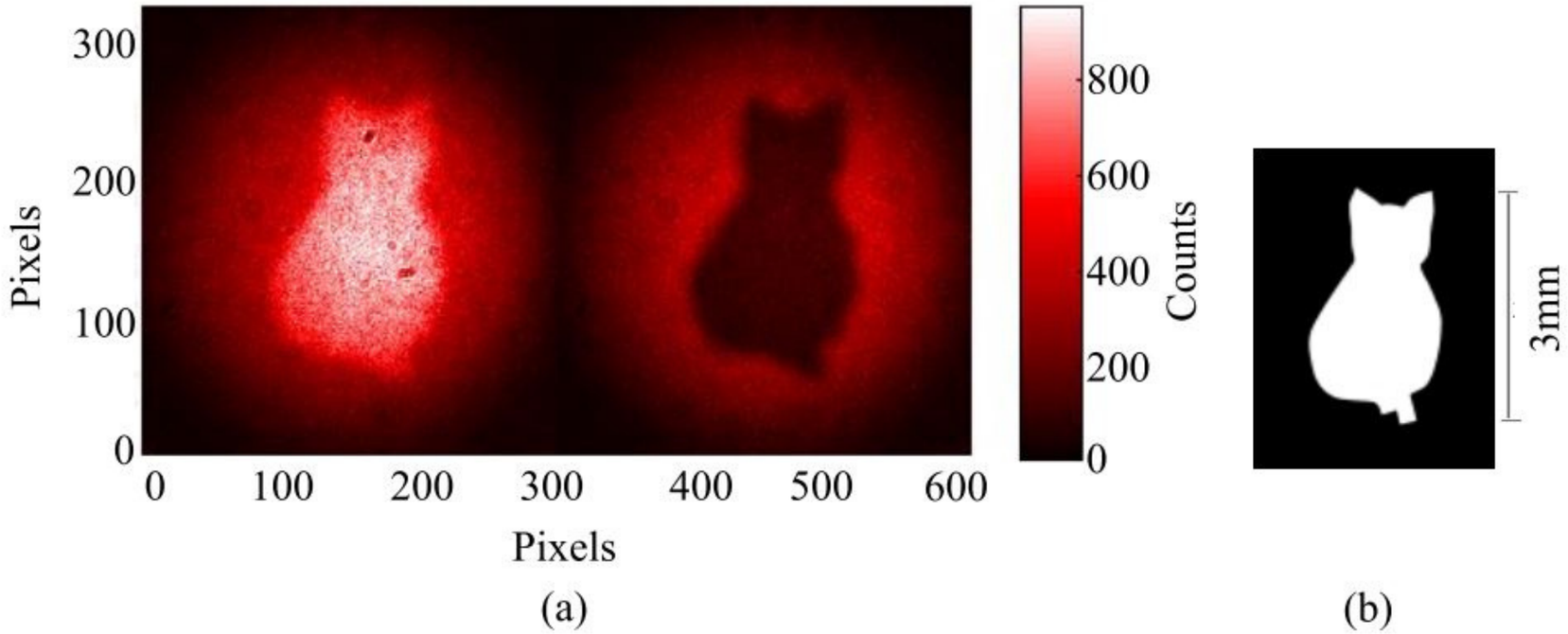
# O QuBit




- Natureza probabilística
- Superposição
- Medidas colapsam o sistema

$$|\psi\rangle = \alpha\,|0\rangle + \beta\,|1\rangle$$

# Emaranhamento




Fonte: Imagem extraída de: LEMOS, Gabriela Barreto et al. Quantum imaging with undetected photons. Nature, v. 512, n. 7515, p. 409-412, 2014.

$$|\psi\rangle = \alpha\,|00\rangle + \beta\,|01\rangle + \gamma\,|10\rangle + \delta\,|11\rangle$$

# Aplicando o Entrelaçamento

$|0\rangle$

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

$|1\rangle$

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

# Aplicando o Entrelaçamento

$|0\rangle$

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

$|1\rangle$

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

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

# Aplicando o Entrelaçamento

$|0\rangle$

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

$|1\rangle$

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

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

# Aplicando o Entrelaçamento

$|0\rangle$

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

$|1\rangle$

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

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

# Aplicando o Entrelaçamento

$|0\rangle$

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

$|1\rangle$

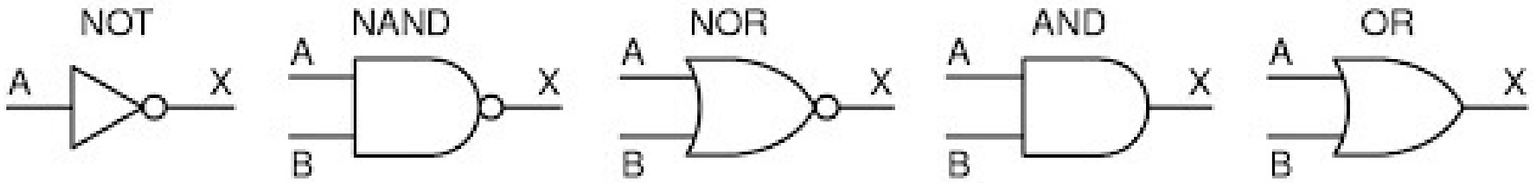
$$\begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

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

Combinação Linear dos estados

# Portas Lógicas & Portas Quânticas

# Portas Lógicas Clássicas




| A | X |
|---|---|
| 0 | 1 |
| 1 | 0 |

(a)

| A | B | X |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

(b)

| A | B | X |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

(c)

| A | B | X |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

(d)

| A | B | X |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

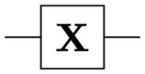
(e)


Fonte: http://www.dpi.inpe.br/~carlos/Academicos/Cursos/ArqComp/aula_5bn1.html

# Portas Quânticas

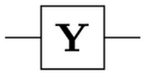
Pauli-X

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




Pauli-Y

$$\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$$




Pauli-Z

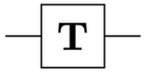
$$\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$


Hadamard

$$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$$

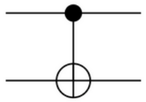

Pi/8

$$\begin{pmatrix} 1 & 0 \\ 0 & e^{\frac{i\pi}{4}} \end{pmatrix}$$



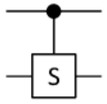

Controlled-Not

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



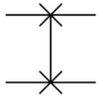
Controlled-Phase

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




Swap

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

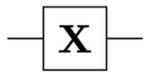


# Aplicando as Portas

$$|0\rangle \qquad |1\rangle$$

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

# Aplicando as Portas

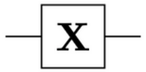
$|0\rangle$ $|1\rangle$  $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} =$

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

# Aplicando as Portas

$|0\rangle$ $|1\rangle$

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

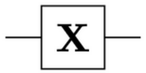



$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

# Aplicando as Portas

$|0\rangle$ $|1\rangle$

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



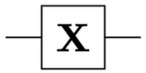

$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$

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

# Aplicando as Portas

$|0\rangle$ $|1\rangle$

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



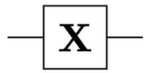

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

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

# Aplicando as Portas

$|0\rangle$ $|1\rangle$

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




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

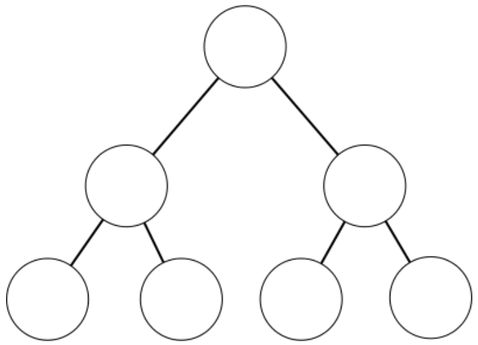
$$\begin{pmatrix}0 & 1\\1 & 0\end{pmatrix}\begin{pmatrix}0\\1\end{pmatrix} = \begin{pmatrix}1\\0\end{pmatrix}$$

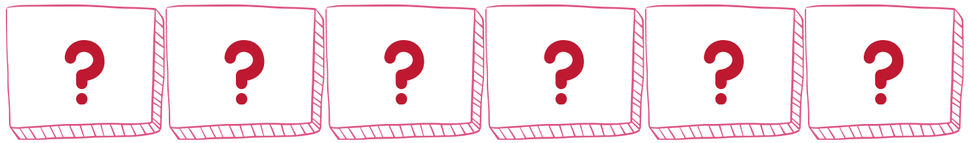
A porta Pauli-X funciona como NOT

# Algoritmos Quânticos


# Algoritmo de Grover

- Desenvolvido por Lov Grover em 1996
- Algoritmo de busca em bancos desordenados
- Comparação entre os algoritmos clássicos e o de Grover
- Probabilistico com custo de $O(\sqrt{N})$

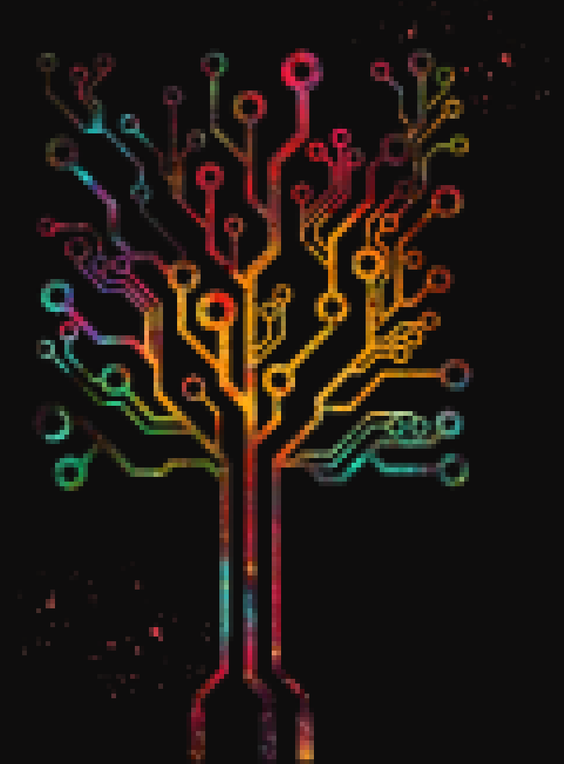




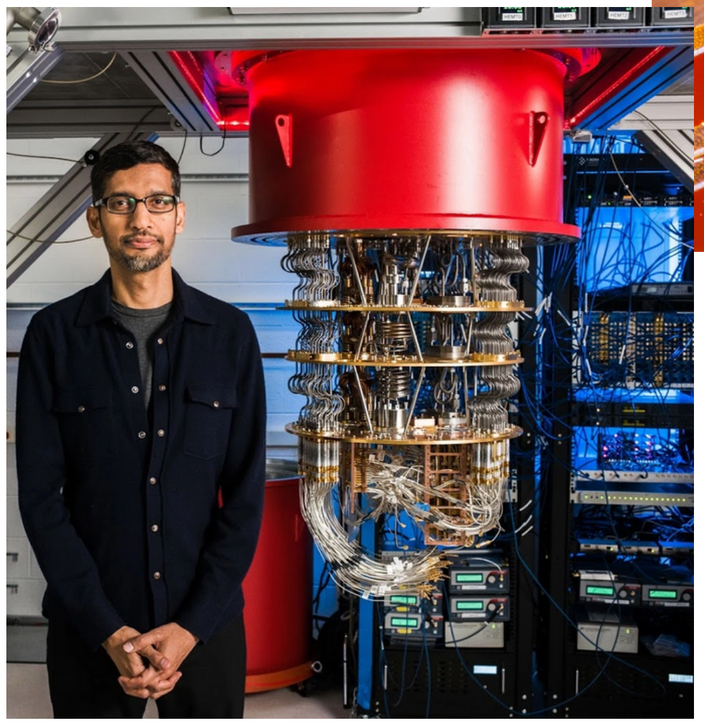

# Algoritmo de Shor

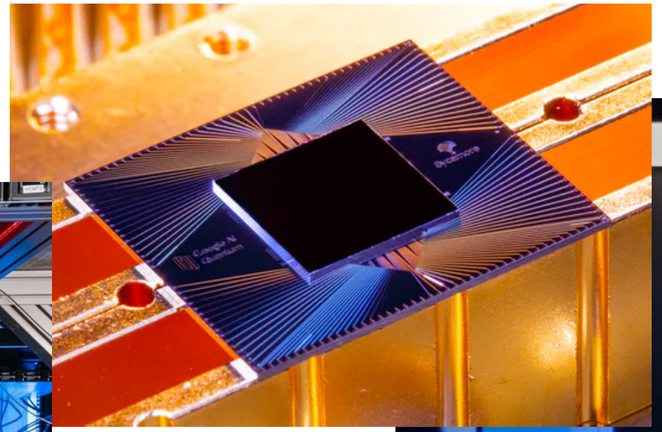
- Desenvolvido por Peter Shor em 1996
- Algoritmo de fatoração em números primos
- Quebra da criptografia atual
- Computadores atuais ainda não o executam

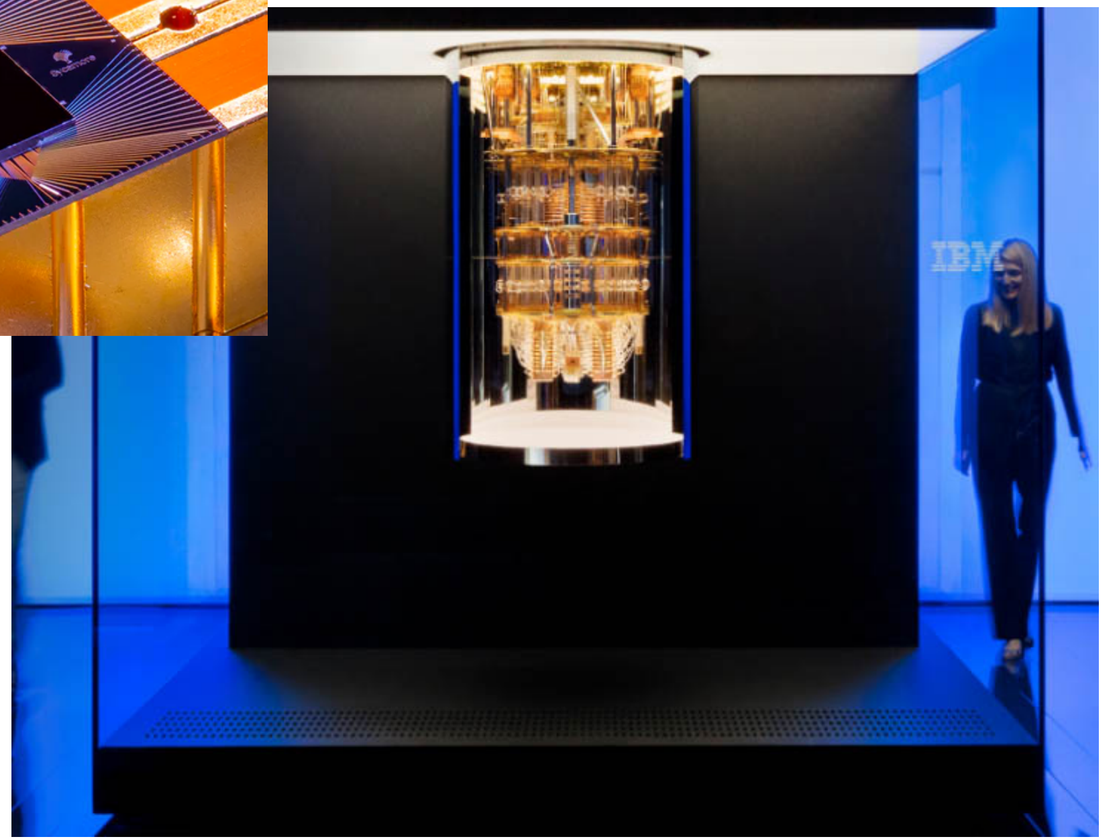
# A Computação Quântica Atualmente



# Computadores Quanticos Atuais





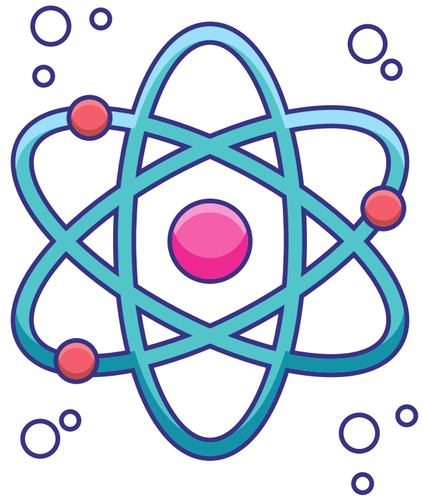


# Mão na Massa

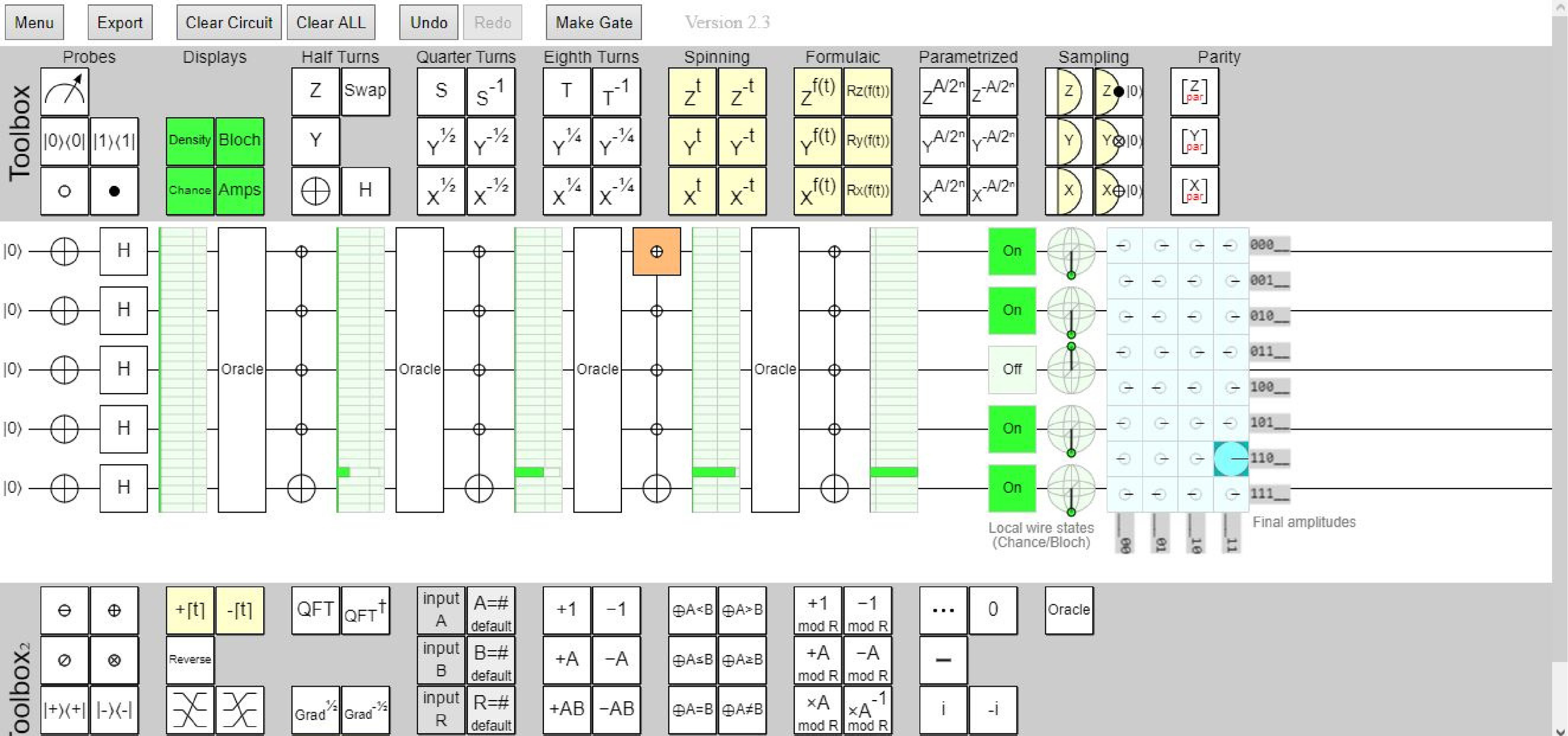
Simuladores e Bibliotecas

# Plataforma Quirk

- Disponível online
- Desenvolvido em JavaScript
- Conta com circuitos pré-programados
- A programação é feita "arrastando blocos"
- Código-fonte disponível no GitHub (Open Source)
- Tutorial disponível no YouTube

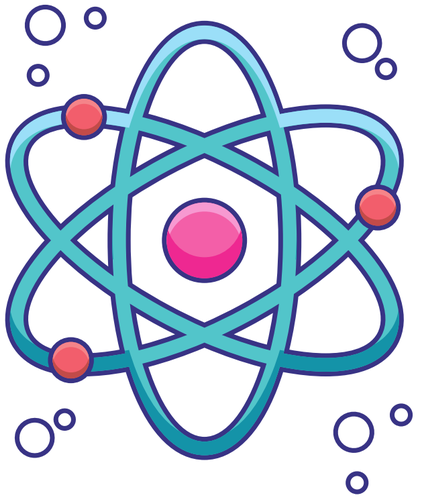


# Plataforma Quirk

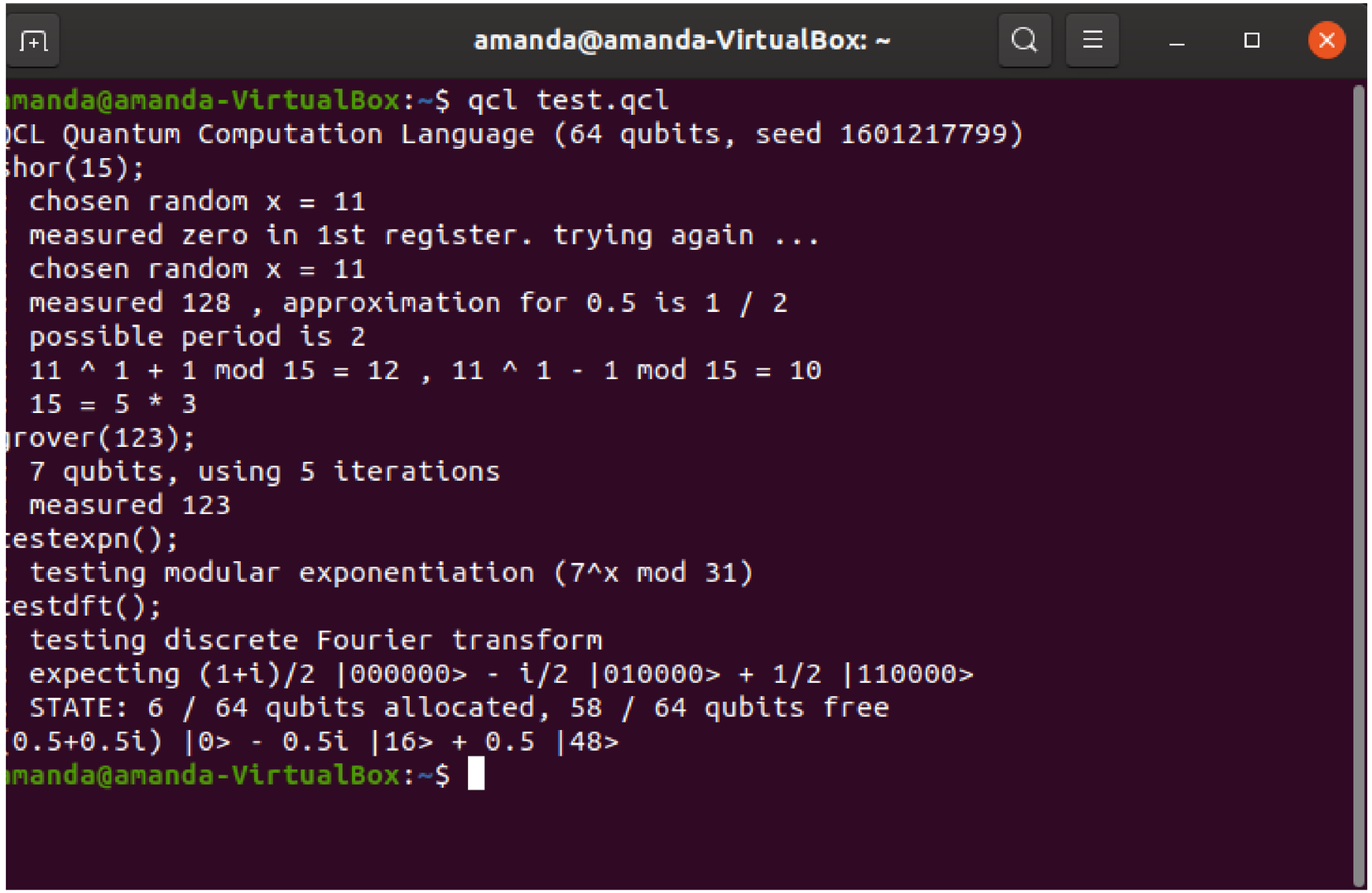


# Simulador QCL

- Open Source
- Desenvolvido em C para sistemas Linux
- Operações e algoritmos pré-programados
- Programação utilizando a linguagem QCL
- Open Source
- Documentação no site do desenvolvedor

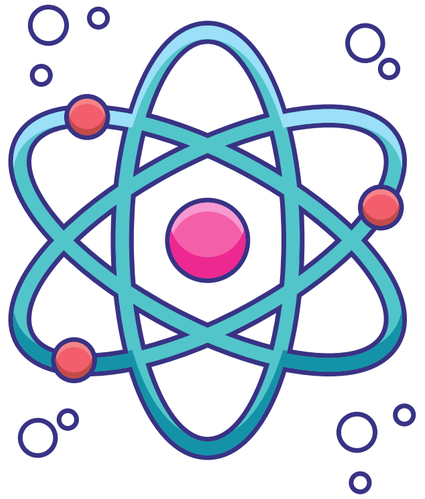


# Simulador QCL

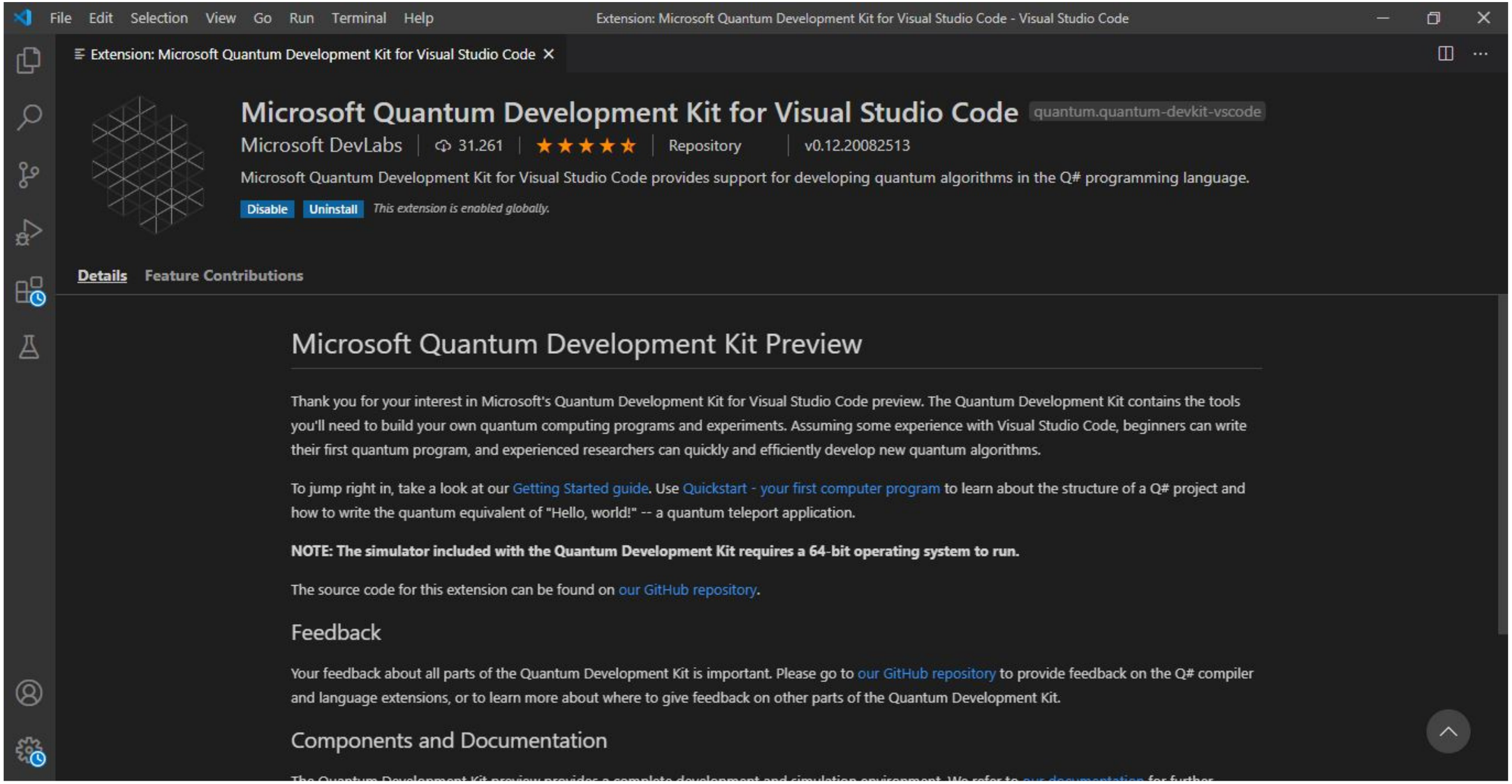


# Microsoft Q# e QDK

- Software Livre
- Conjunto de bibliotecas numéricas, para machine learning e química
- É compatível com Python, C# e VB.NET
- Jupyter, Visual Code e Visual Studio



# Microsoft Q# e QDK



# IBM QisKit

- Programa Open Source
- Pode ser utilizado localmente ou online
- Ferramenta gráfica para programar circuitos quânticos
- Utiliza Python
- Usando a Quantum Experience, é possível executar os circuitos em computadores quânticos da IBM**

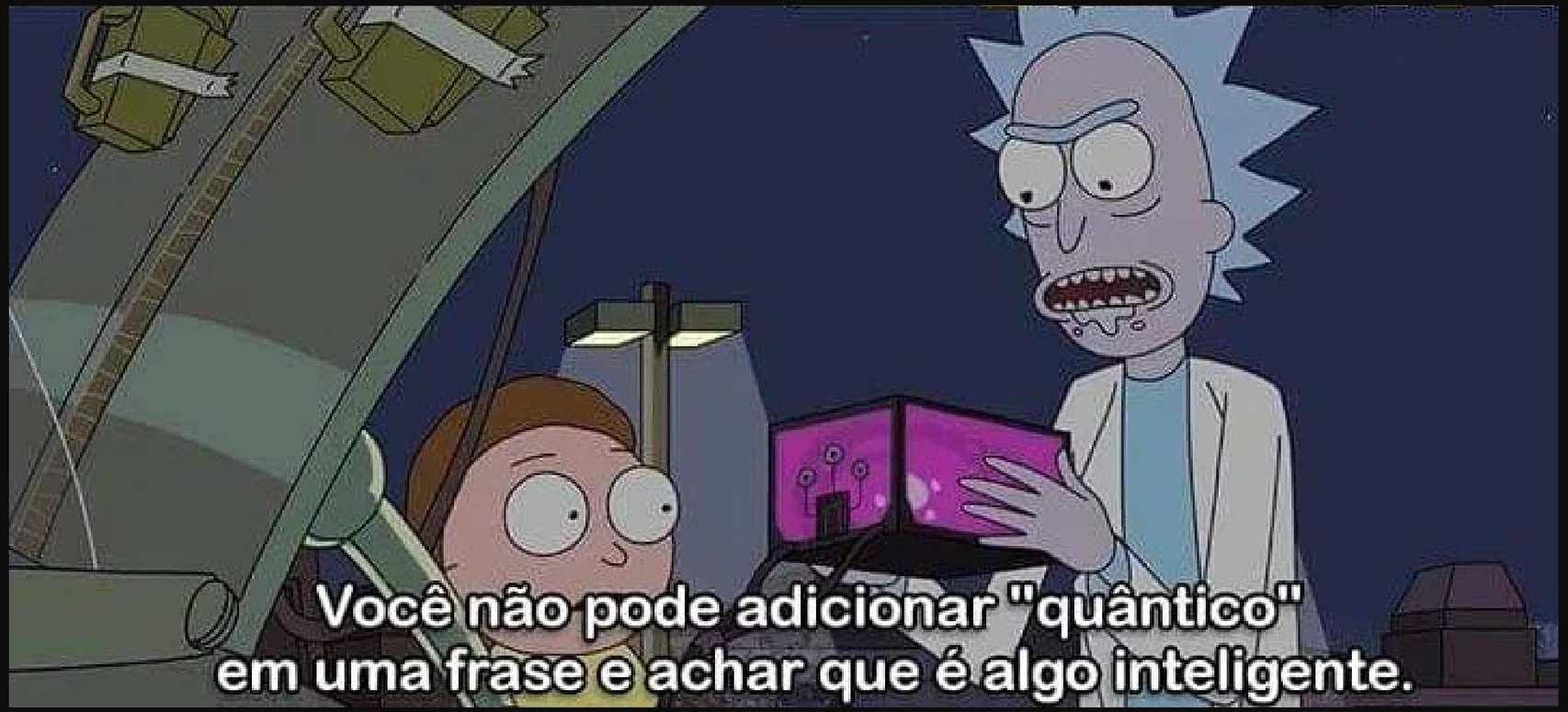
# Cirq

- Open Source
- Utilizado para pequenos circuitos
- Biblioteca de Python
- Suporte para programar computadores quânticos da Google

# E muitas outras opções...

Você pode acessar a lista de simuladores e bibliotecas em:

https://www.quantiki.org/wiki/list-qc-simulators




Obs. final: a quântica não vai melhorar a sua vida, ela só afeta partículas e objetos microscópios. Desconfie de tudo que você ouvir com este termo, verifique as fontes e sempre estude.

# Thank you

## Dúvidas?

amanda.valerio@alunos.ifsuldeminas.edu.br