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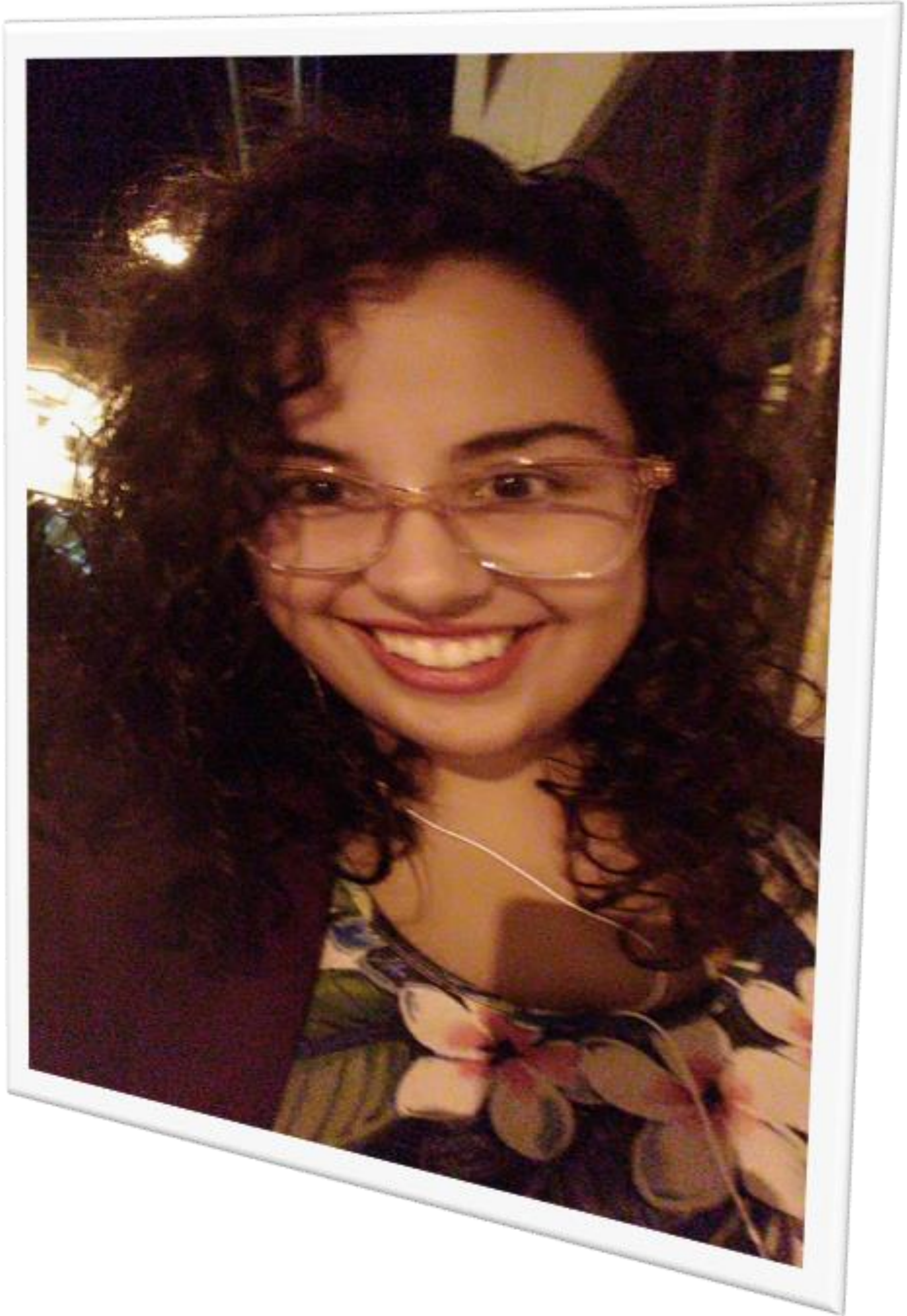
A Computação Quântica no Cenário Atual

Daniele Nazaré Tavares

Felipe Emanoel Chaves

Quem Sou Eu?

Eu sou uma nerd e autoditada, apaixonada por tecnologia, cinema, livros, ciência [***E muito Doida***]. Estuda Engenharia de Computação no Inatel, e faço parte da organização do Flisol Santa Rita do Sapucaí.



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Contato

Dany.nt.14@gmail.com

https://github.com/danynt14

https://www.linkedin.com/in/danielenazare/

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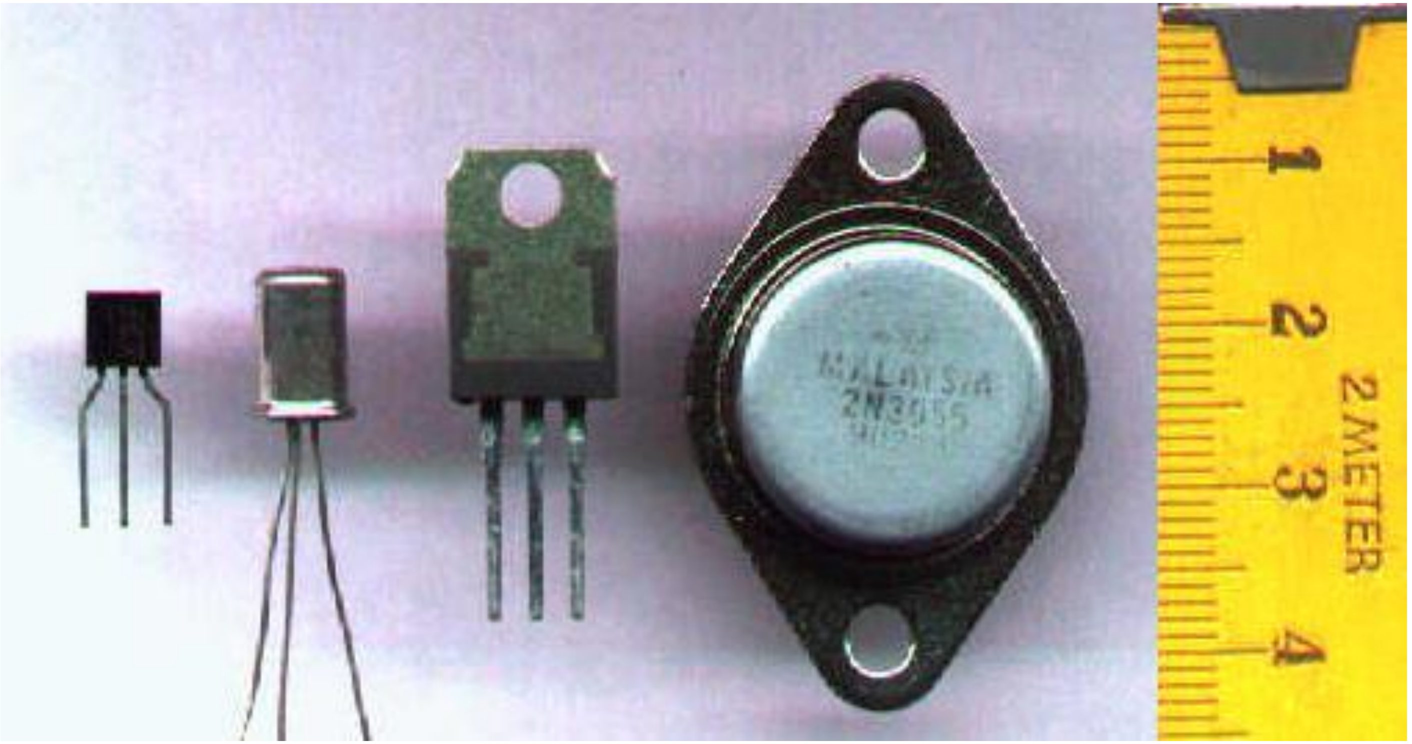
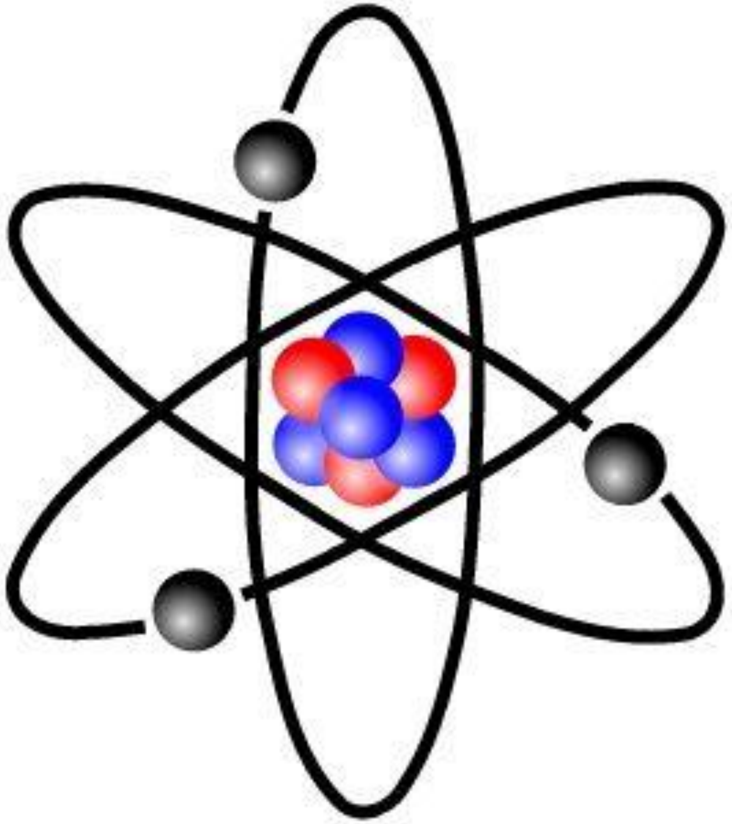
Intro

Miniatuarização do Transistor



Miniatuarização do Transistor

$\Rightarrow$



Velocidade da Luz = 299 792 458 m / s

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Empresas

IBM

HUAWEI

accenture

Google

D-Wave
The Quantum Computing Company™

Microsoft

Computação

"A computação é um fenômeno que busca executar cálculos através de processos físicos, em tempo finito, com fixos e distinguíveis conjunto de estados definidos"

S. S. Sysoev

[Saint Petersburg State University](#)

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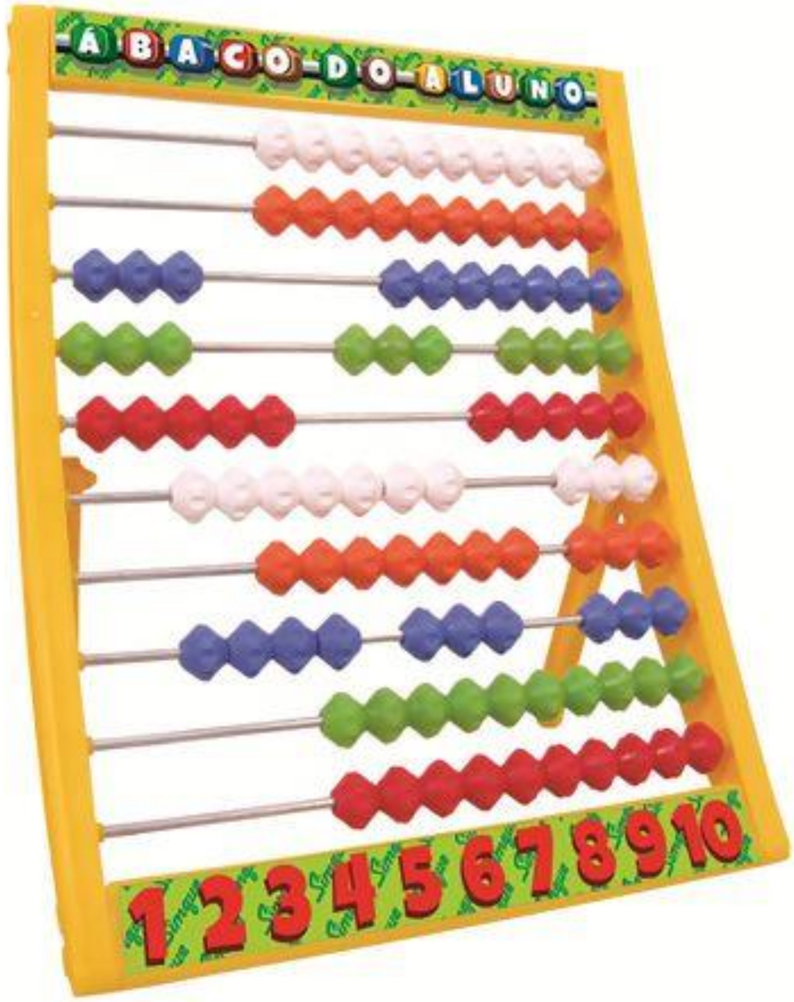
Computação



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Características do Sistema Computacional

1. Quantidade de informação que o sistema consegue armazenar ao longo do tempo
2. Frequência de mudança entre os estados
3. Universalidade que está relacionado com o conjunto de tarefas que um modelo consegue resolver.

S. S. Sysoev

[Saint Petersburg State University]

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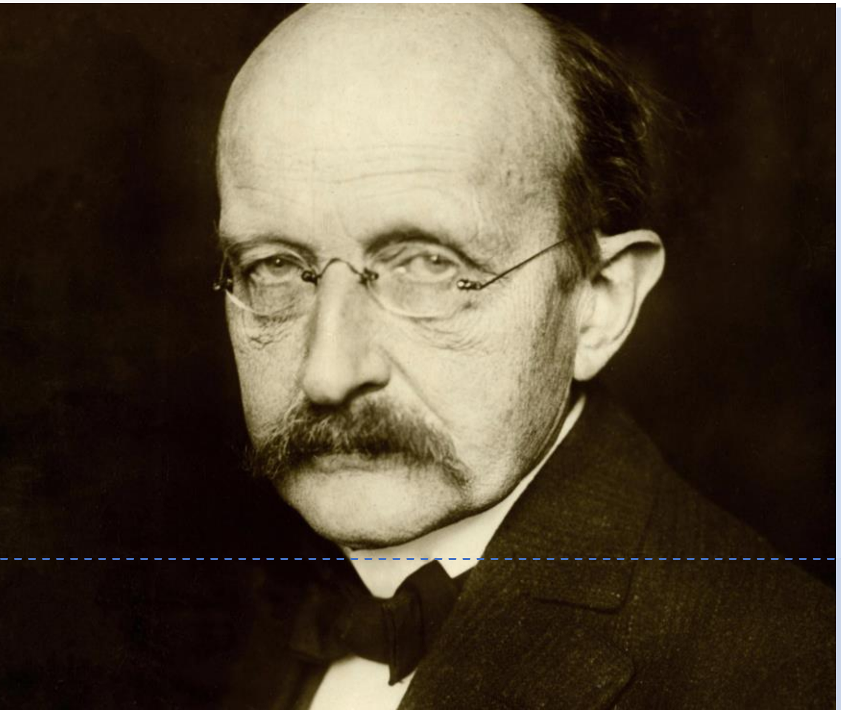


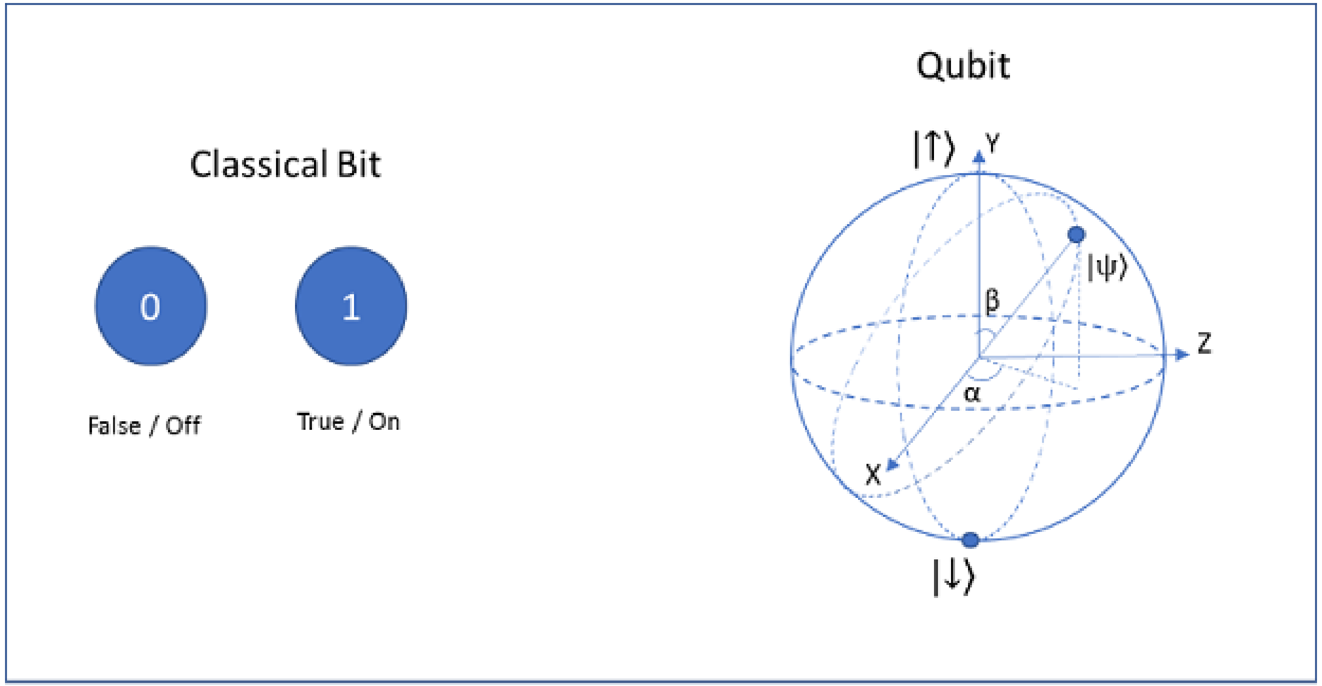
Computação Quântica

"Probabilidade e Incerteza"

1. Incerteza de Heinsenberg
2. Radiação de Corpo Negro de Max Planck

Computação Quântica

Bit vs. quBit



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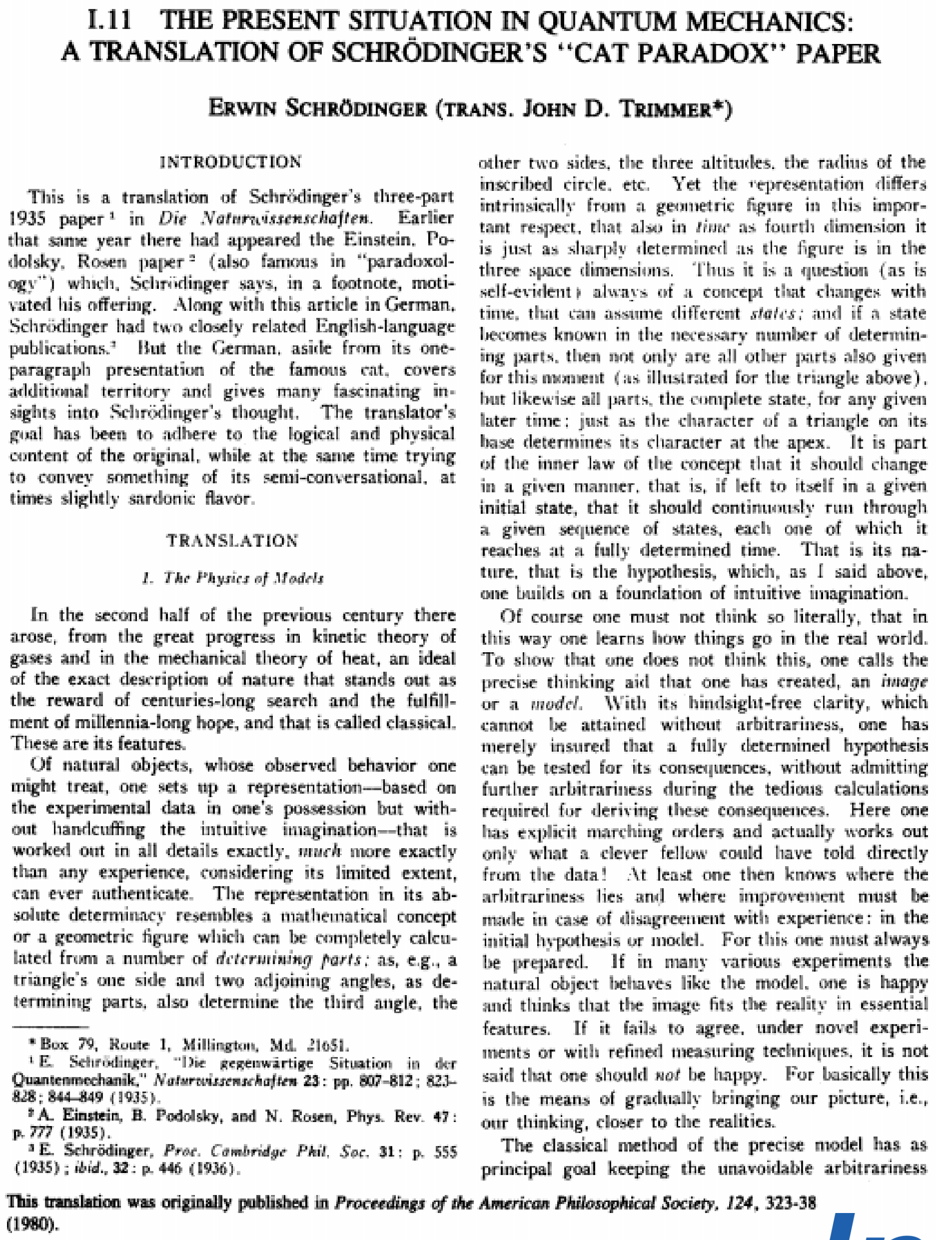
Computação Quântica

Experimento do Gato de Schrödinger[35]



I.11 THE PRESENT SITUATION IN QUANTUM MECHANICS: A TRANSLATION OF SCHRÖDINGER'S "CAT PARADOX" PAPER

ERWIN SCHRÖDINGER (TRANS. JOHN D. TRIMMER*)

INTRODUCTION

This is a translation of Schrödinger's three-part 1935 paper[1] in *Die Naturwissenschaften*. Earlier that same year there had appeared the Einstein, Podolsky, Rosen paper[2] (also famous in "paradoxology") which, Schrödinger says, in a footnote, motivated his offering. Along with this article in German, Schrödinger had two closely related English-language publications.[3] But the German, aside from its one-paragraph presentation of the famous cat, covers additional territory and gives many fascinating insights into Schrödinger's thought. The translator's goal has been to adhere to the logical and physical content of the original, while at the same time trying to convey something of its semi-conversational, at times slightly sardonic flavor.

TRANSLATION

1. *The Physics of Models*

In the second half of the previous century there arose, from the great progress in kinetic theory of gases and in the mechanical theory of heat, an ideal of the exact description of nature that stands out as the reward of centuries-long search and the fulfillment of millennia-long hope, and that is called classical. These are its features.

Of natural objects, whose observed behavior one might treat, one sets up a representation—based on the experimental data in one's possession but without handcuffing the intuitive imagination—that is worked out in all details exactly, *much* more exactly than any experience, considering its limited extent, can ever authenticate. The representation in its absolute determinacy resembles a mathematical concept or a geometric figure which can be completely calculated from a number of *determining parts*; as, e.g., a triangle's one side and two adjoining angles, as determining parts, also determine the third angle, the other two sides, the three altitudes, the radius of the inscribed circle, etc. Yet the representation differs intrinsically from a geometric figure in this important respect, that also in *time* as fourth dimension it is just as sharply determined as the figure is in the three space dimensions. Thus it is a question (as is self-evident) always of a concept that changes with time, that can assume different *states*; and if a state becomes known in the necessary number of determining parts, then not only are all other parts also given for this moment (as illustrated for the triangle above), but likewise all parts, the complete state, for any given later time; just as the character of a triangle on its base determines its character at the apex. It is part of the inner law of the concept that it should change in a given manner, that is, if left to itself in a given initial state, that it should continuously run through a given sequence of states, each one of which it reaches at a fully determined time. That is its nature, that is the hypothesis, which, as I said above, one builds on a foundation of intuitive imagination.

Of course one must not think so literally, that in this way one learns how things go in the real world. To show that one does not think this, one calls the precise thinking aid that one has created, an *image* or a *model*. With its hindsight-free clarity, which cannot be attained without arbitrariness, one has merely insured that a fully determined hypothesis can be tested for its consequences, without admitting further arbitrariness during the tedious calculations required for deriving these consequences. Here one has explicit marching orders and actually works out only what a clever fellow could have told directly from the data! At least one then knows where the arbitrariness lies and where improvement must be made in case of disagreement with experience: in the initial hypothesis or model. For this one must always be prepared. If in many various experiments the natural object behaves like the model, one is happy and thinks that the image fits the reality in essential features. If it fails to agree, under novel experiments or with refined measuring techniques, it is not said that one should *not* be happy. For basically this is the means of gradually bringing our picture, i.e., our thinking, closer to the realities.

The classical method of the precise model has as principal goal keeping the unavoidable arbitrariness

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* Box 79, Route 1, Millington, Md. 21651.

1 E. Schrödinger, "Die gegenwärtige Situation in der Quantenmechanik," *Naturwissenschaften* **23**: pp. 807–812; 823–828; 844–849 (1935).

2 A. Einstein, B. Podolsky, and N. Rosen, Phys. Rev. **47**: p. 777 (1935).

3 E. Schrödinger, *Proc. Cambridge Phil. Soc.* **31**: p. 555 (1935); *ibid.*, **32**: p. 446 (1936).

This translation was originally published in *Proceedings of the American Philosophical Society*, 124, 323-38 (1980).

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Quem idealizou a possibilidade de processamento de dados com a mecânica quântica?

Feynman sugeriu o modelo universal de computação quântica relacionado com princípios básicos e leis da mecânica quântica de natureza probabilística [3]

Pai da Computação Quântica

David Deutsch propôs um modelo matemático de máquina de turing quântica.

Propôs a ideia de Porta Lógica Quântica Universal

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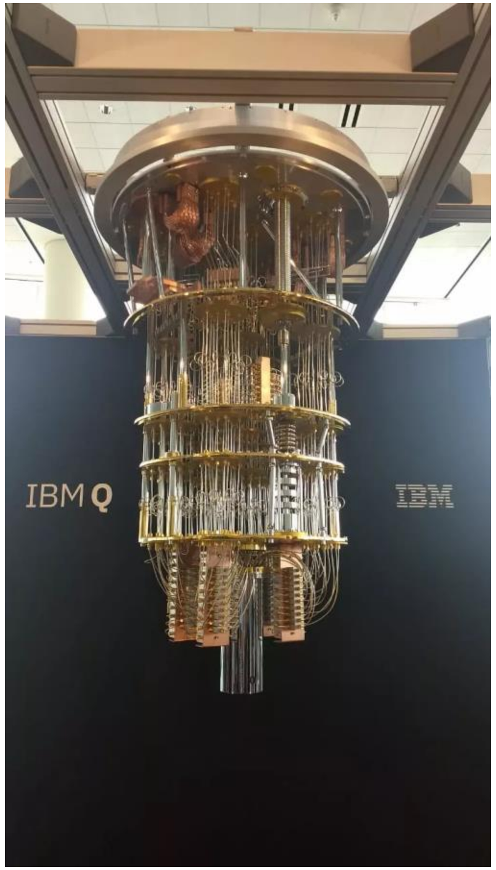
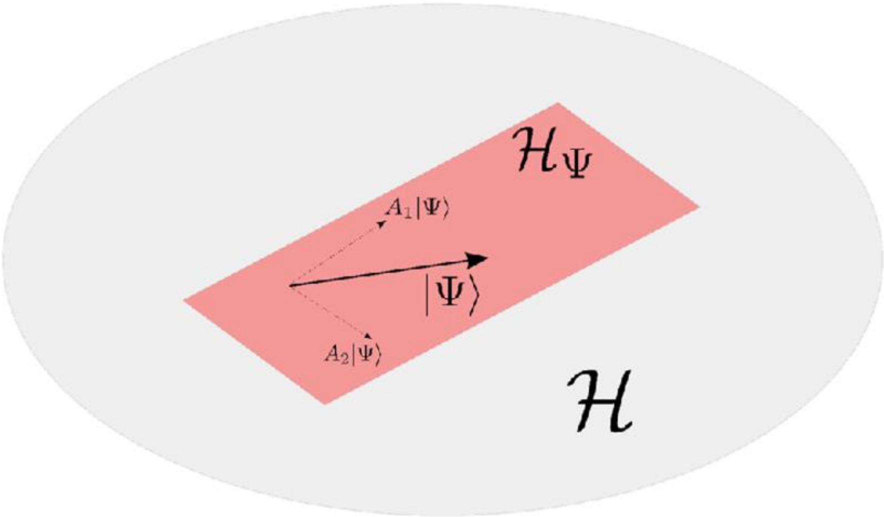
Maior Problema do Computador Quântico



Isolamento Perfeito

Computação Clássica vs. Quântica

Álgebra Booleana
Mecânica Clássica
Caráter Determinístico
0 ou 1



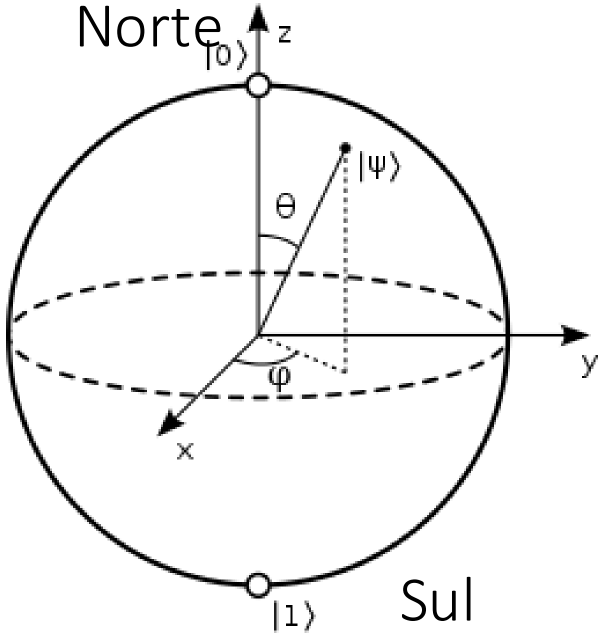
Espaço de Hilbert
Mecânica Quântica
Caráter Probabilístico
0 e 1

Computação Clássica vs. Quântica

0: Cara/ Falso

1: Coroa / Verdadeiro

0 / 1



Sobreposição de estados quânticos

Ket |ψ>

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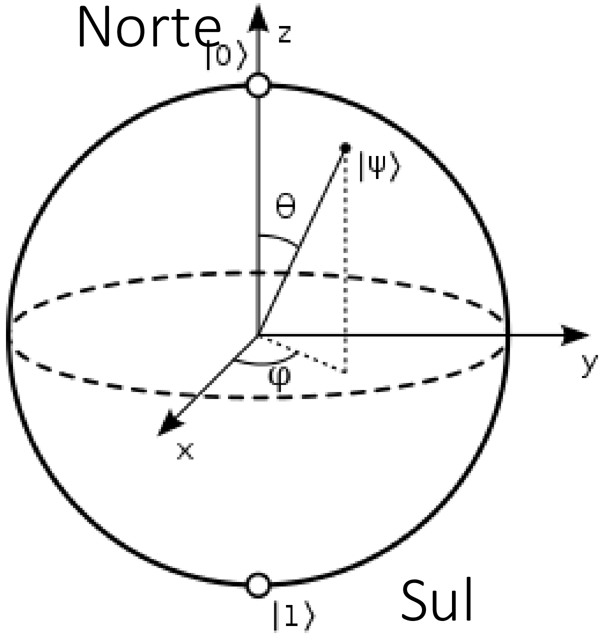
Computação Clássica vs. Quântica

Portas lógicas clássicas são irreversíveis

Perda Termodinâmica

Norte



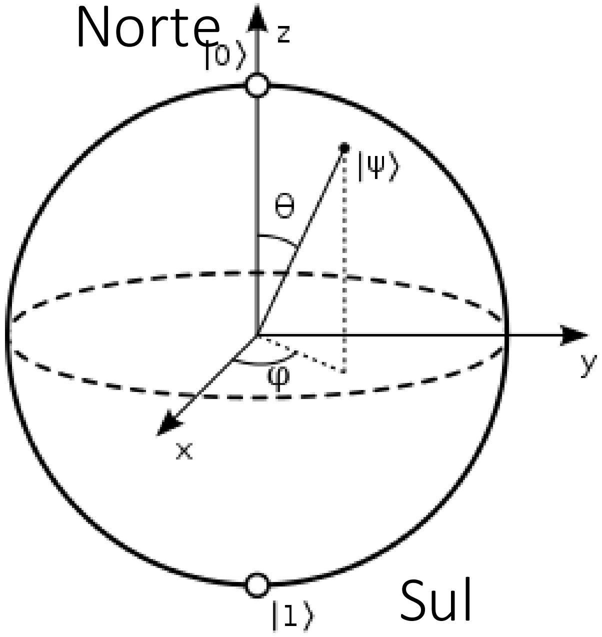
Sul

Portas Lógicas Quânticas

são reversíveis

Computação Clássica vs. Quântica

Medida fisíca: Corrente elétrica



Medida fisíca: Colapso do Sistema

TABLE I
ILUSTRA A QUANTIDADE DE BITS QUE CADA QUBIT POSSUI .

quBit (n)	Bits (2^n)	Bytes
1	2	–
2	4	–
3	8	1
4	16	2
5	32	4
6	64	8
7	128	16
8	256	32
9	512	64
10	1024	128
15	32768	4096
20	1048576	131072
25	33554432	4194304
50	1.1258999e+15	1.4073749e+14
75	3.7778932e+22	4.7223665e+21
100	1.2676506e+30	1.5845633e+29

Na computação quântica, armazena-se mais informações em regiões menores e utiliza-se a álgebra linear do Espaço de Hilbert junto aos princípios lógicos de acordo com a propriedade superposição de estados da mecânica quântica [19]

Portas Lógicas

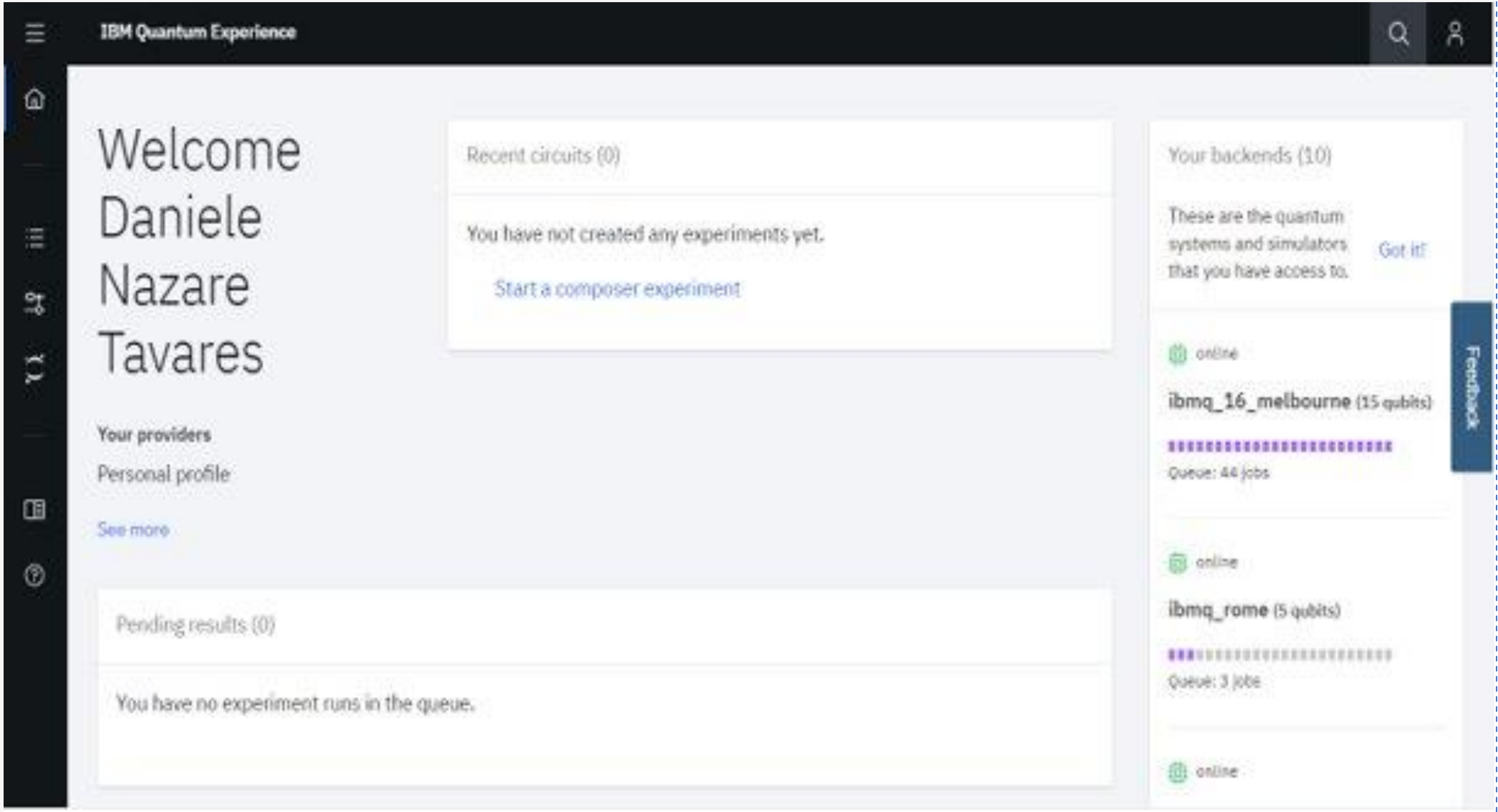
TABLE II
ILUSTRA PORTAS LÓGICAS QUÂNTICAS DE 1 QUBIT [23] .

Porta lógica	Representação Matemática	Representação Visual
Pauli-X	$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$	X
Pauli-Y	$\begin{pmatrix} 0 & -i \\ -i & 0 \end{pmatrix}$	Y
Pauli-Z	$\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$	Z
Hadamard	$\frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$	H
$\pi/8$ T	$\begin{pmatrix} 1 & 0 \\ 0 & \exp \frac{i\pi}{4} \end{pmatrix}$	T
S	$\begin{pmatrix} 1 & 0 \\ 0 & -i \end{pmatrix}$	S
CX	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix}$	
CZ	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$	
SWAP	$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$	
Toffoli	$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{pmatrix}$	

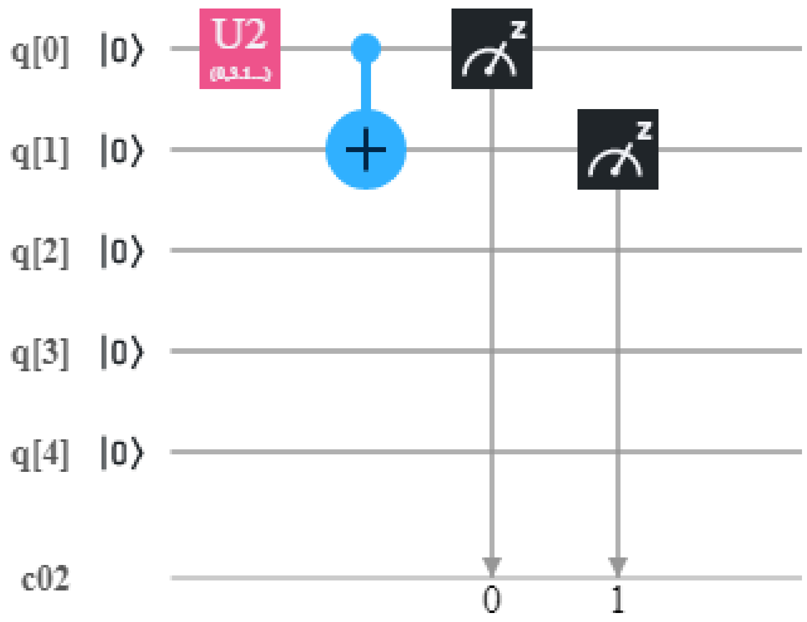
Ferramentas de simulação e Linguagens

1. Qiskit
2. IonQ
3. Q#
4. QCL (Quantum Computer Language)
5. Silq
6. quTIP
7. Cirq

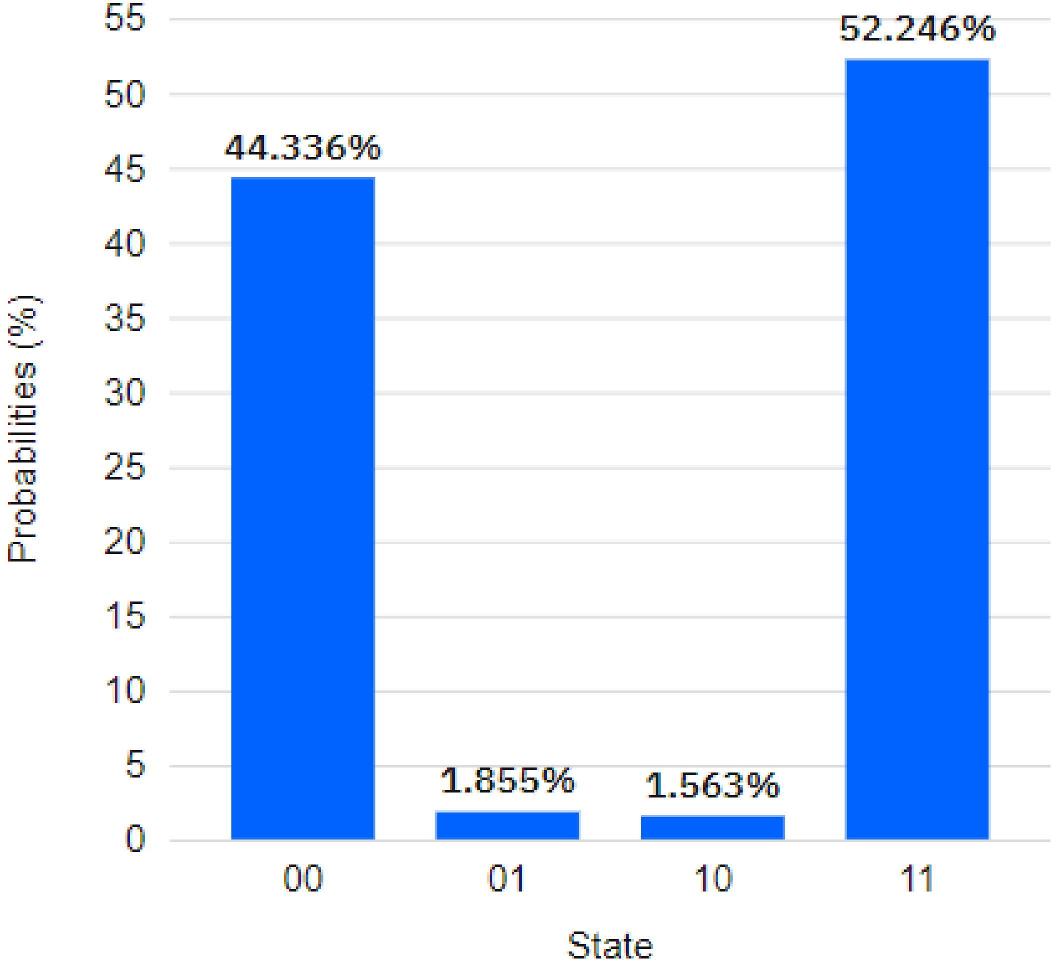
IBM Quantum Experience



Simulação



q[0] |0⟩
q[1] |0⟩
q[2] |0⟩
q[3] |0⟩
q[4] |0⟩
c02
U2
z
z
0
1



Probabilities (%)
55
50
45
40
35
30
25
20
15
10
5
0
44.336%
1.855%
1.563%
52.246%
00
01
10
11
State


Coffee Quantum Wiki

Coffee Quantum Wiki

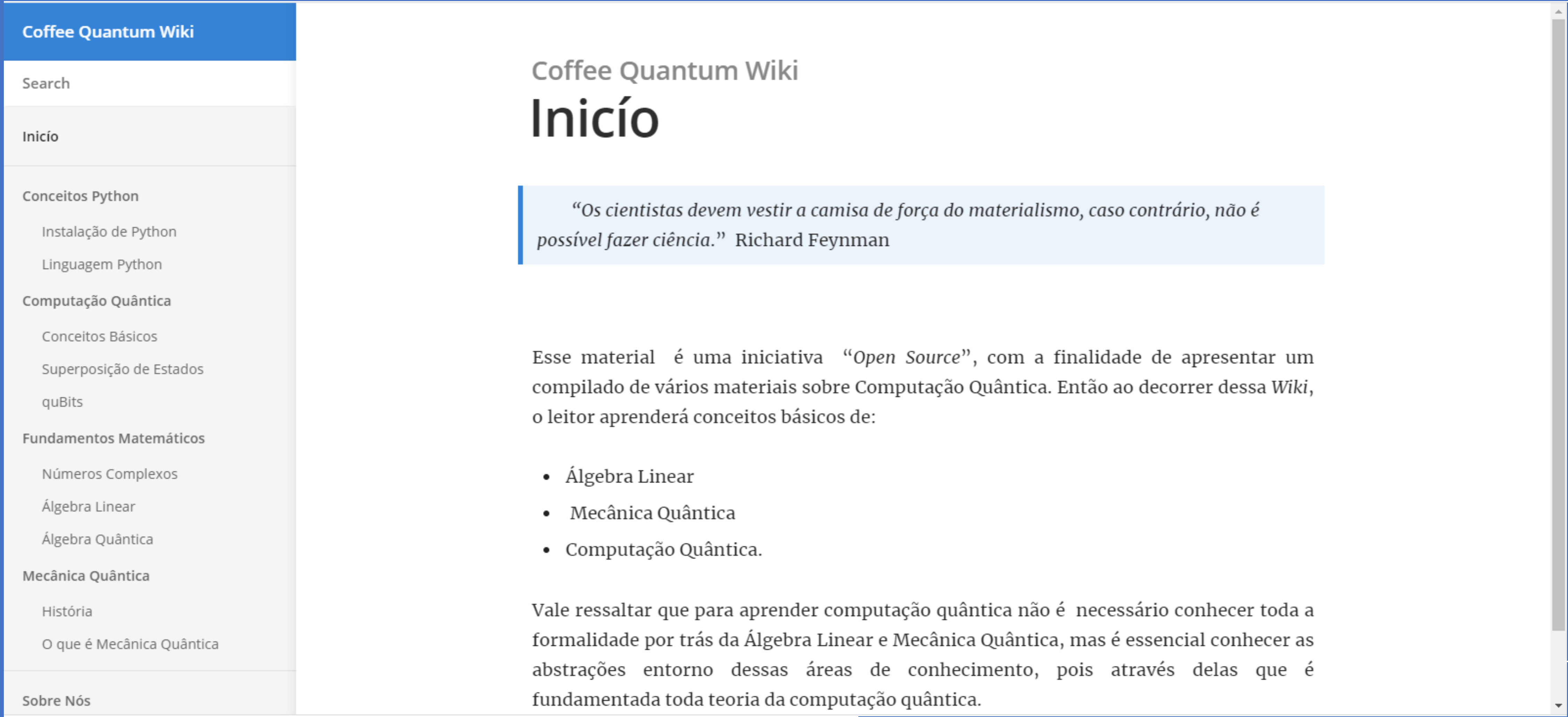
Inicío

> *"Os cientistas devem vestir a camisa de força do materialismo, caso contrário, não é possível fazer ciência."* Richard Feynman

Esse material é uma iniciativa *"Open Source"*, com a finalidade de apresentar um compilado de vários materiais sobre Computação Quântica. Então ao decorrer dessa Wiki, o leitor aprenderá conceitos básicos de:

- Álgebra Linear
- Mecânica Quântica
- Computação Quântica.

Project Coffe Quantum Wiki (Mobile)



Coffee Quantum Wiki

Search

- Inicío
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  - Linguagem Python
- Computação Quântica
  - Conceitos Básicos
  - Superposição de Estados
  - quBits
- Fundamentos Matemáticos
  - Números Complexos
  - Álgebra Linear
  - Álgebra Quântica
- Mecânica Quântica
  - História
  - O que é Mecânica Quântica
- Sobre Nós

Coffee Quantum Wiki

Inicío

> *"Os cientistas devem vestir a camisa de força do materialismo, caso contrário, não é possível fazer ciência."* Richard Feynman

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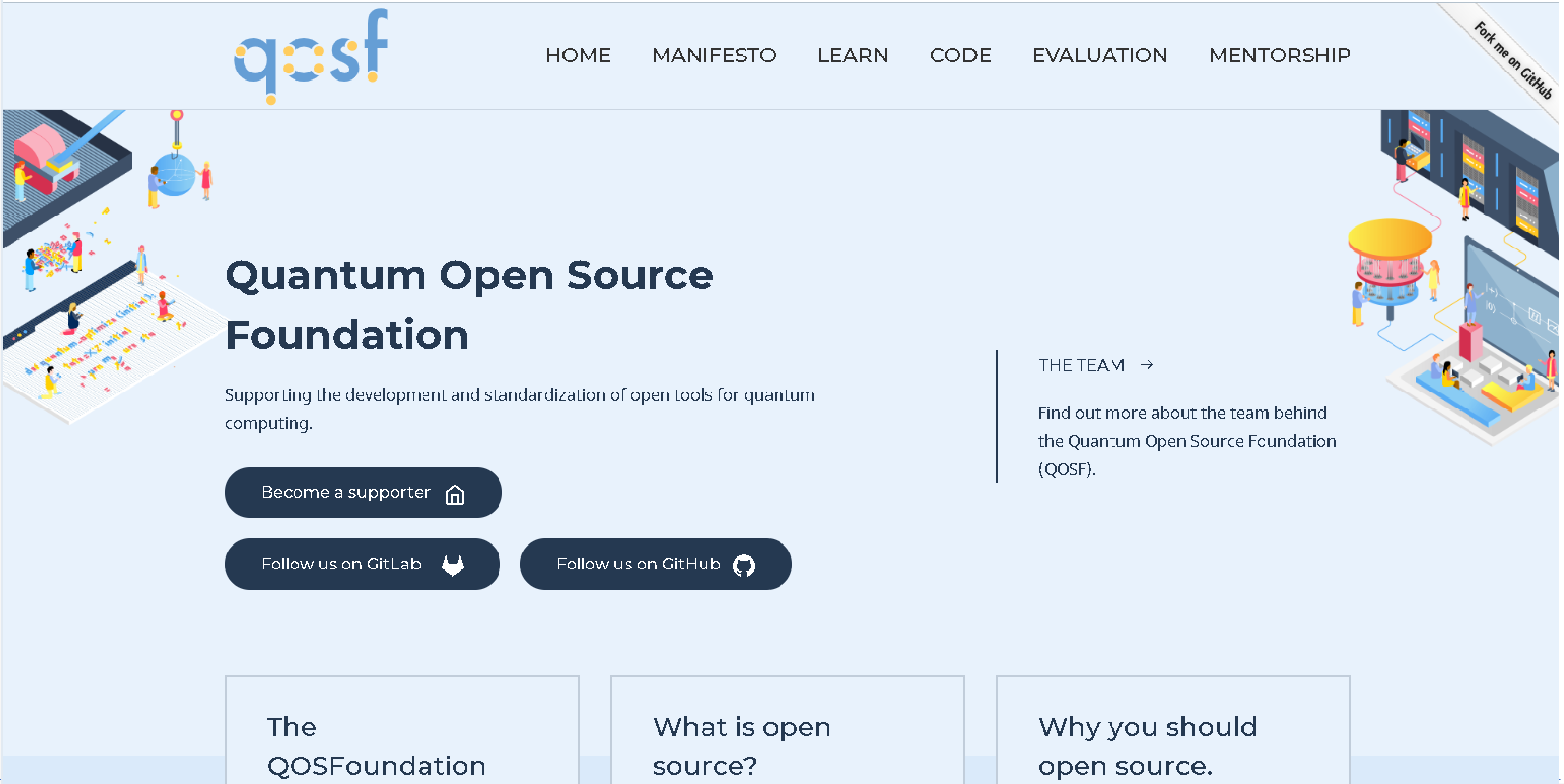
- Álgebra Linear
- Mecânica Quântica
- Computação Quântica.

Vale ressaltar que para aprender computação quântica não é necessário conhecer toda a formalidade por trás da Álgebra Linear e Mecânica Quântica, mas é essencial conhecer as abstrações entorno dessas áreas de conhecimento, pois através delas que é fundamentada toda teoria da computação quântica.

Project Coffe Quantum Wiki (Web)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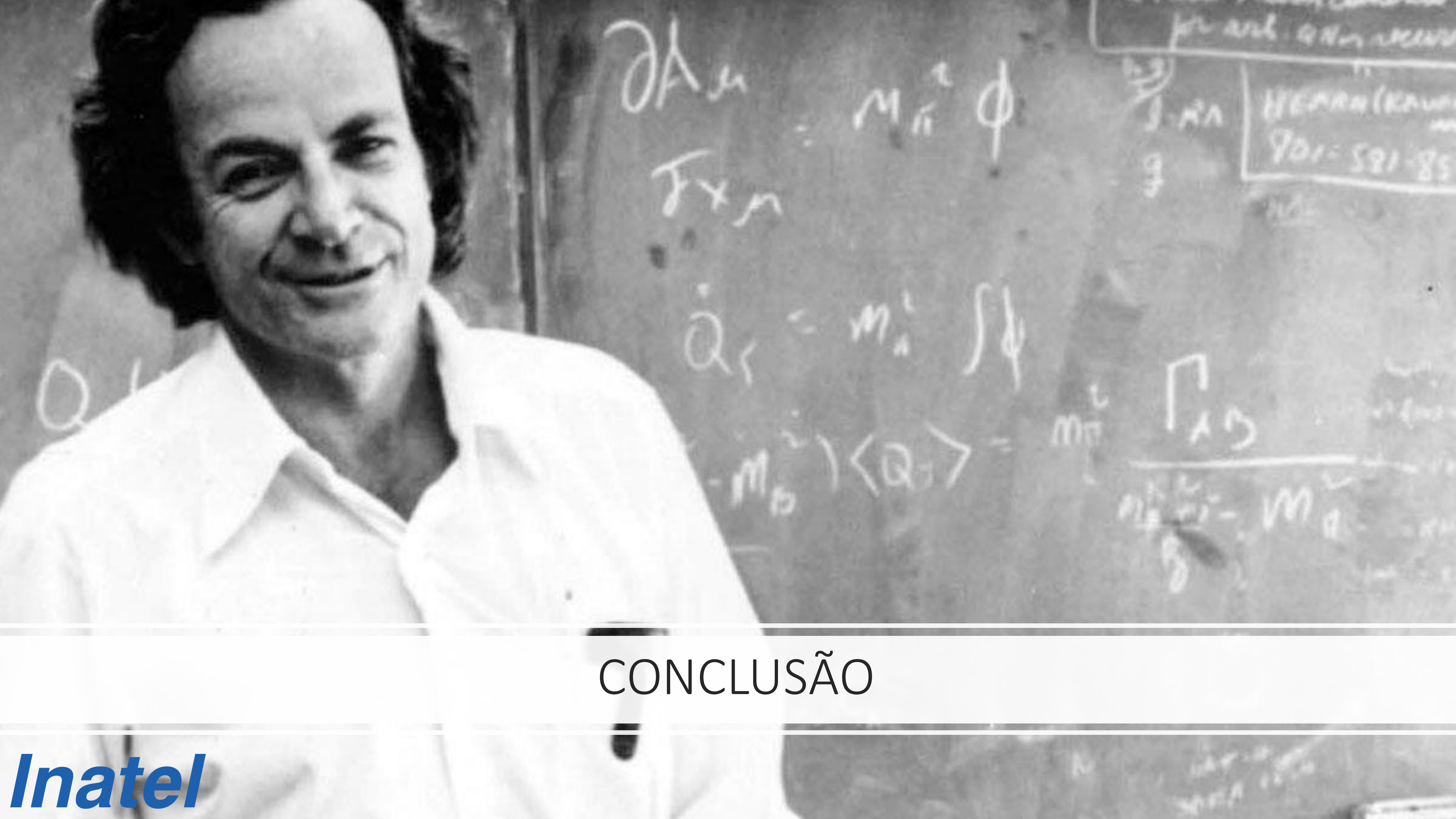
Why you should open source.



CONCLUSÃO

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EU VOU PROCURAR VOCÊS MAIS TARDE PRA ME DAR UMA CARTA DE RECOMENDAÇÃO!

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Thank you!
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grammarly