

DA MECÂNICA QUÂNTICA À NANOTECNOLOGIA

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Setembro, 2008



Escola de Verão de Física



U. PORTO

FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO

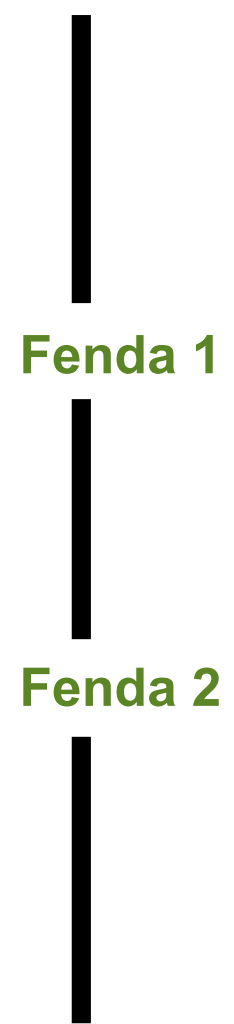
Plano do Curso:

- **Experiência da dupla fenda**
- **Mecânica quântica em todo o lado**
- **Nanotecnologia**
- **Interpretações da mecânica quântica**

Experiência da dupla fenda



Fonte



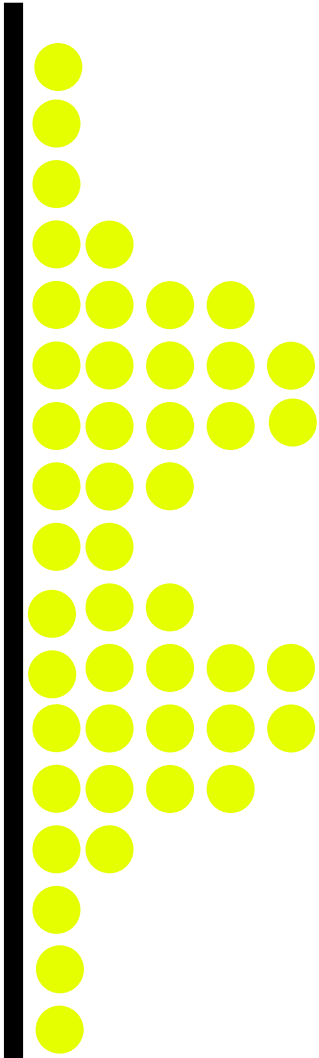
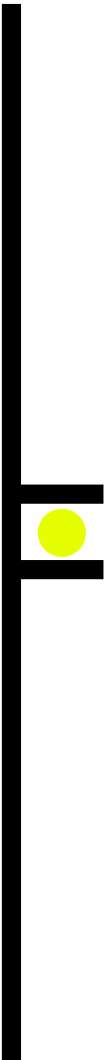
Fenda 1

Fenda 2

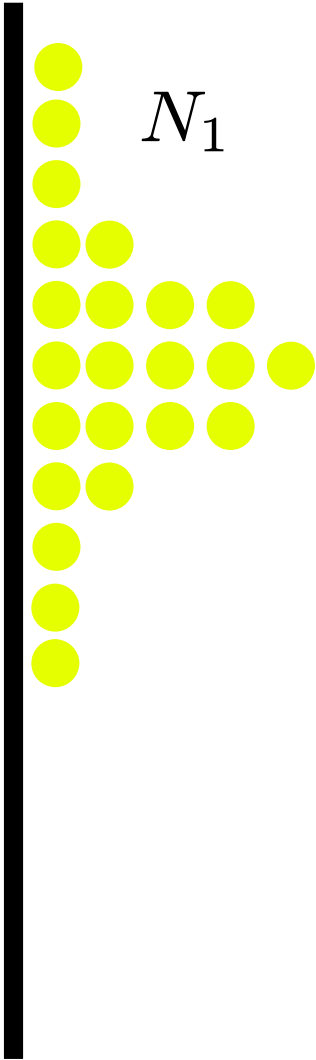
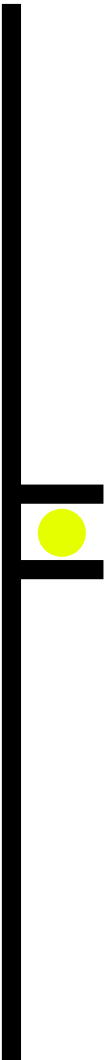


Alvo

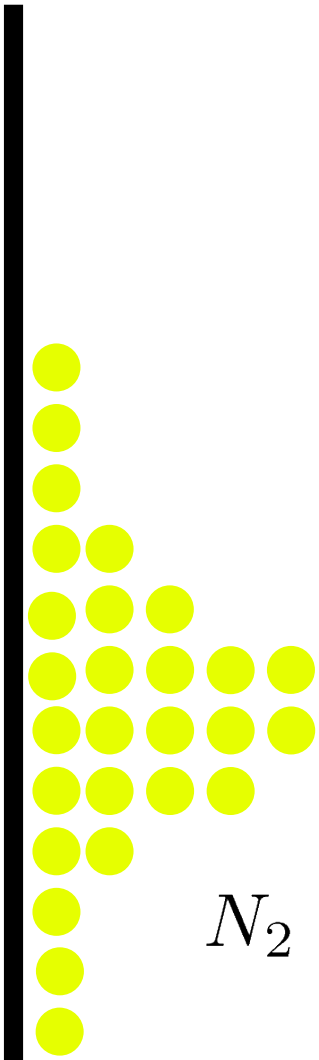
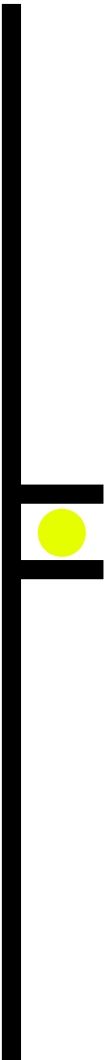
Com bolas



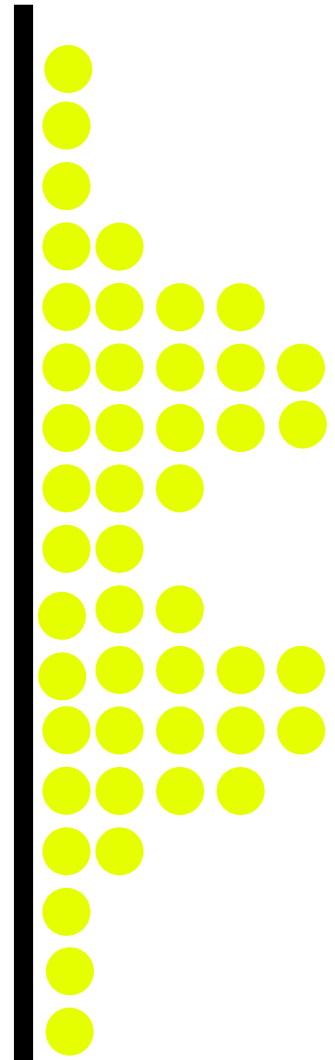
Com bolas



Com bolas

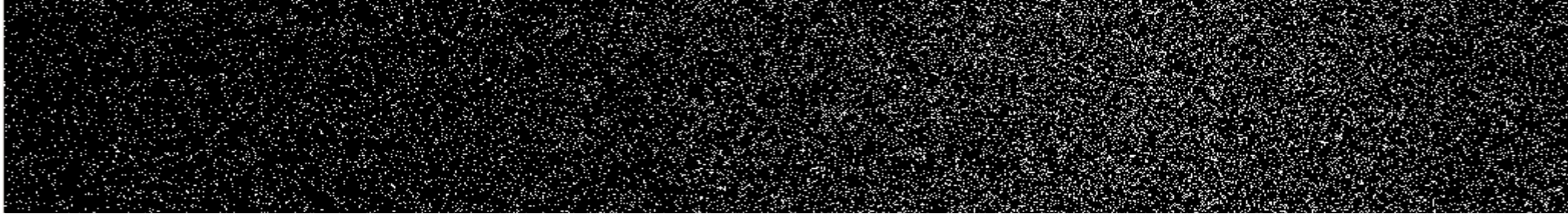


Com bolas

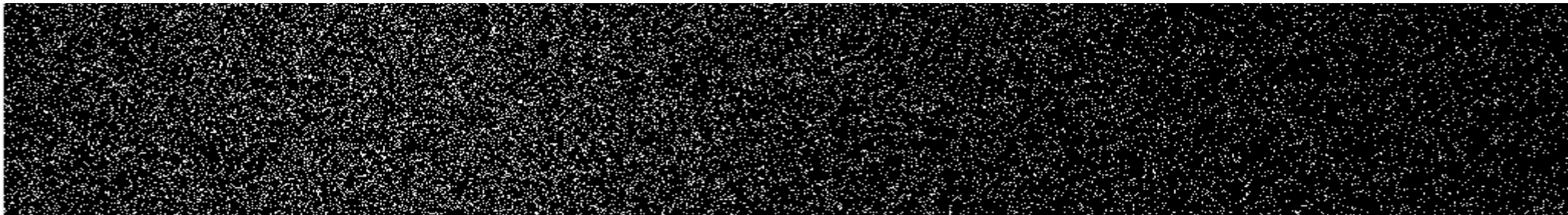


$$N_{12} = N_1 + N_2$$

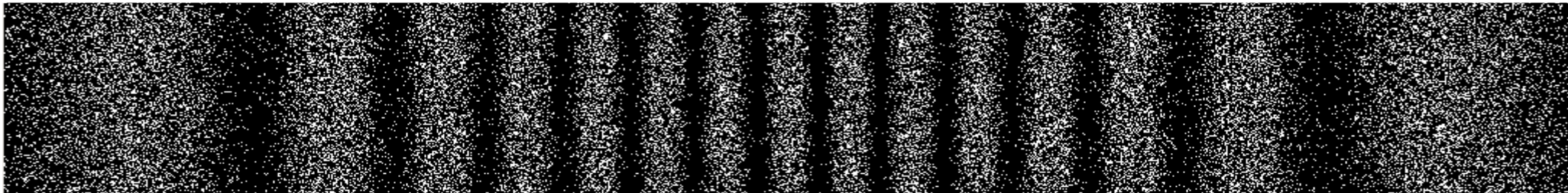
Com electrões



Apenas a fenda 1 aberta

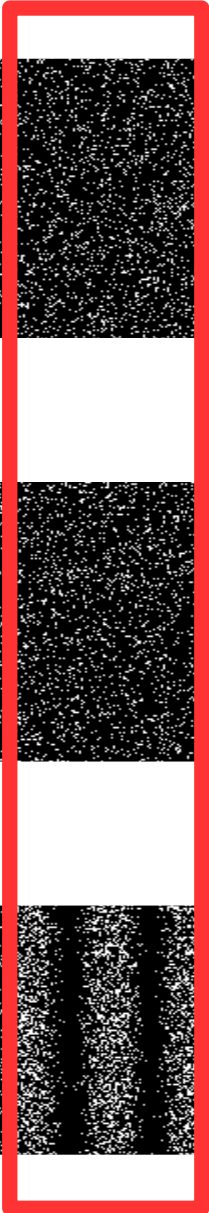
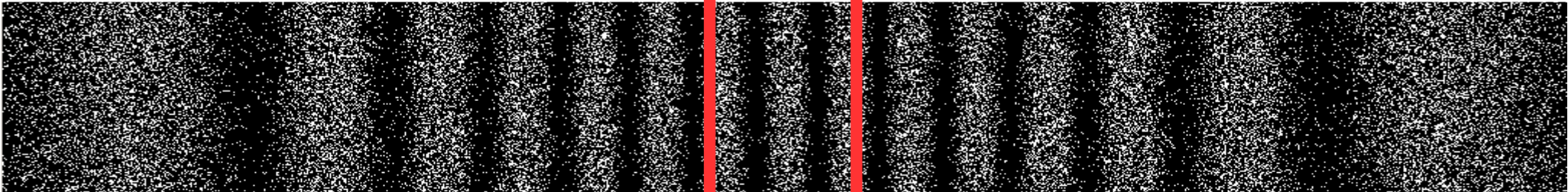
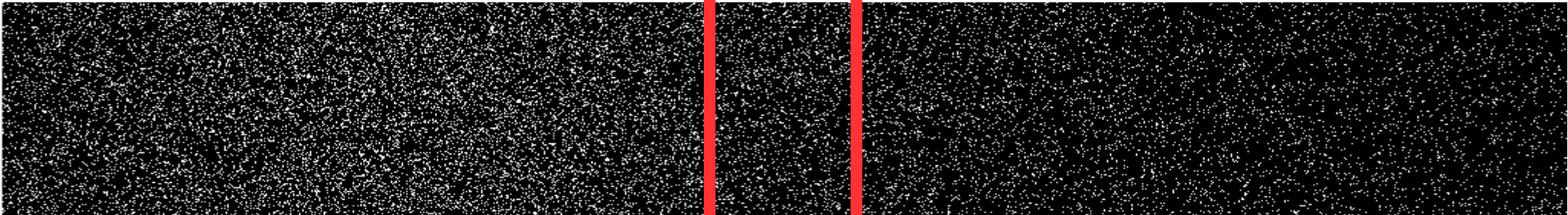
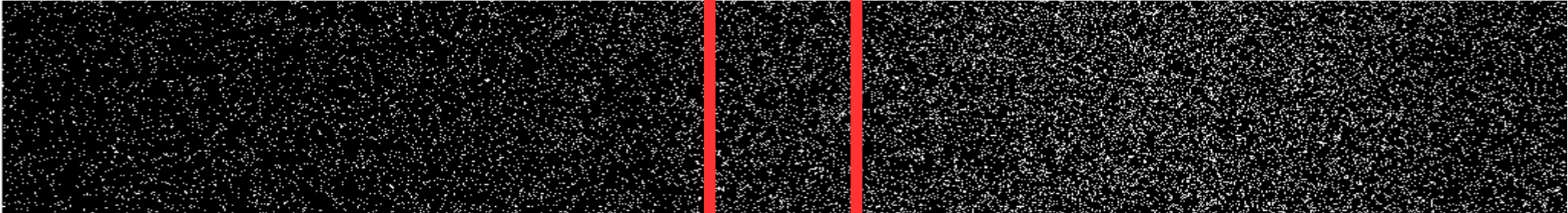


Apenas a fenda 2 aberta

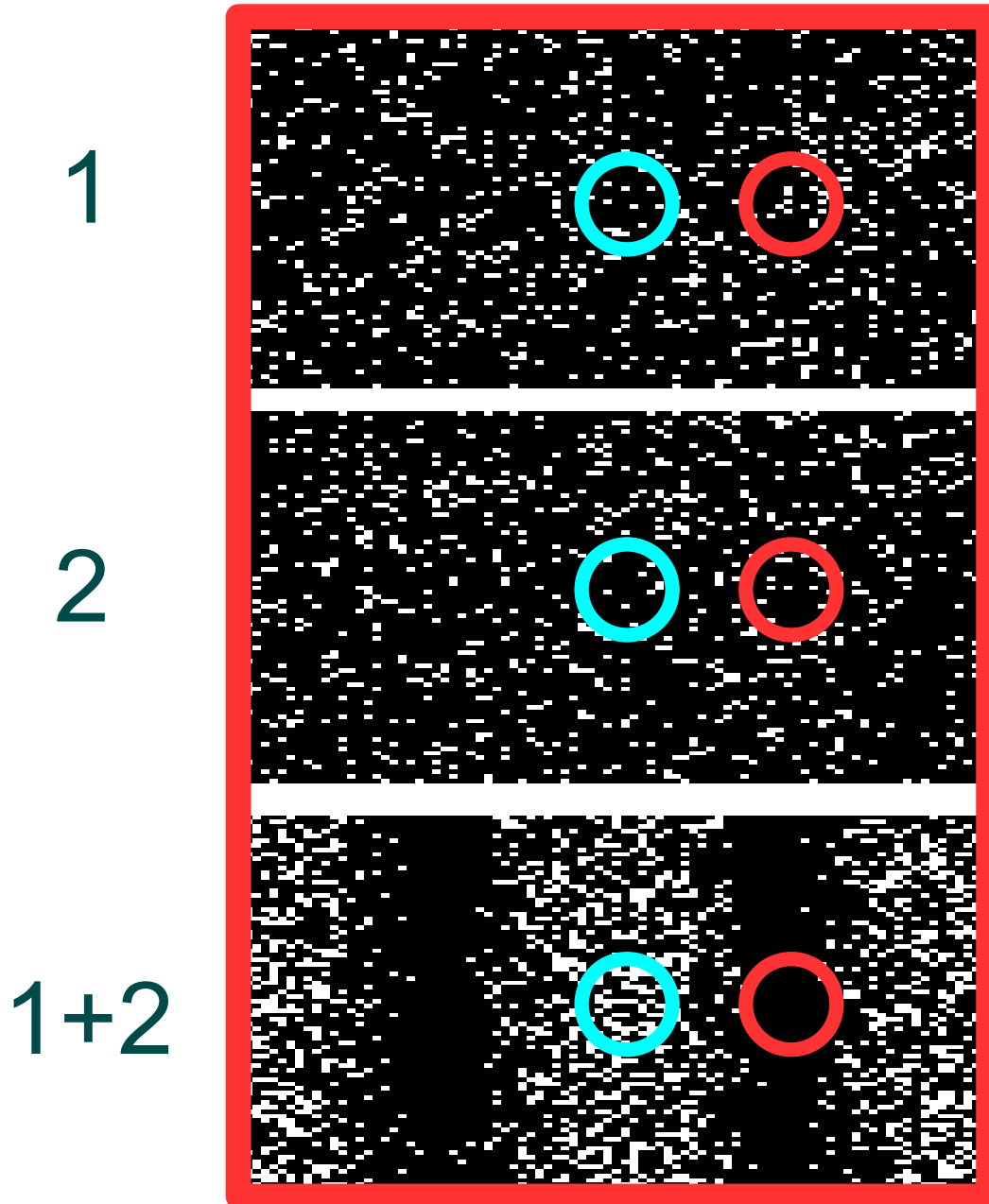


Ambas as fendas abertas

Com electrões



Com electrões



Nota:

Este fenómeno acontece com um electrão de cada vez.

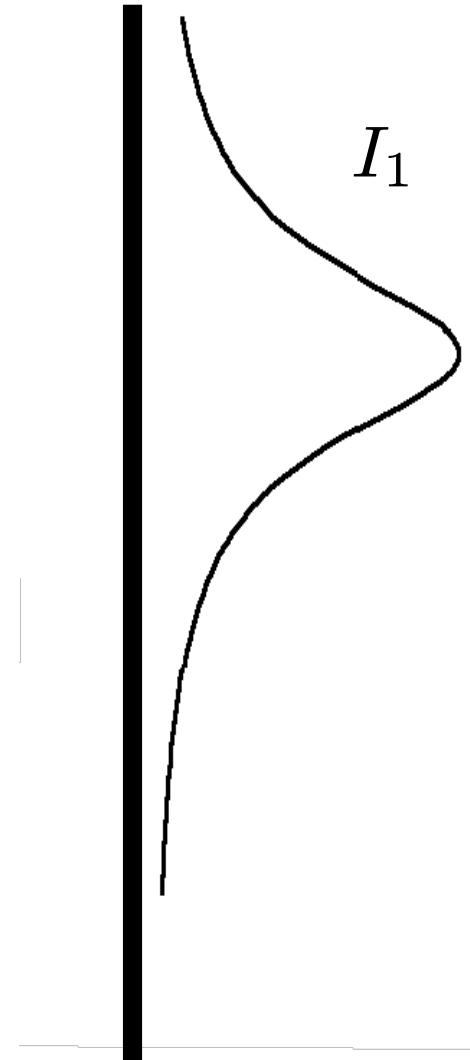
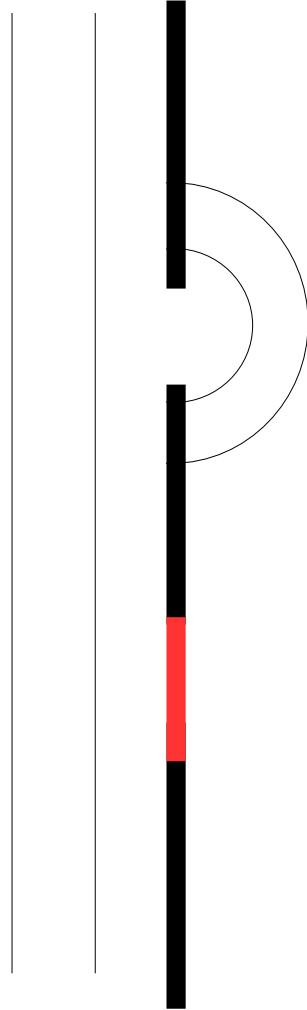
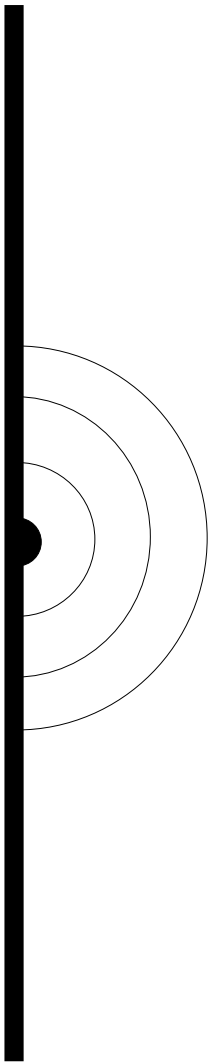
O Electrão ~~ou~~ passa pela fenda 1 ou pela fenda 2.

FALSO

Com ondas?

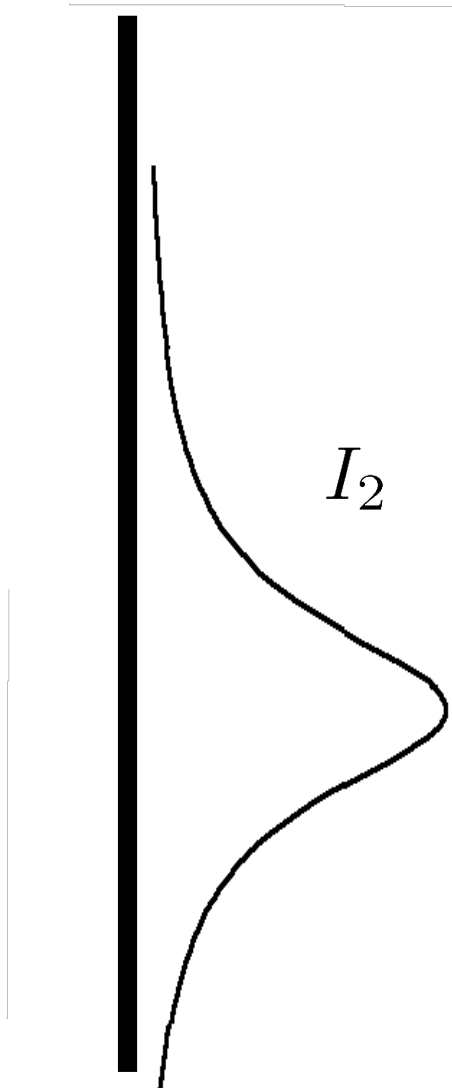
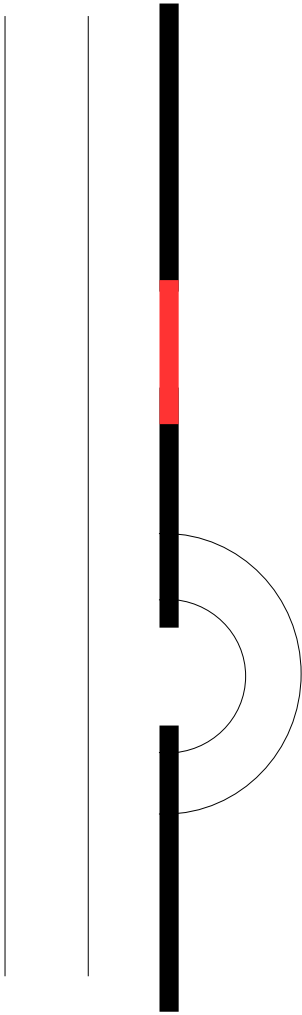
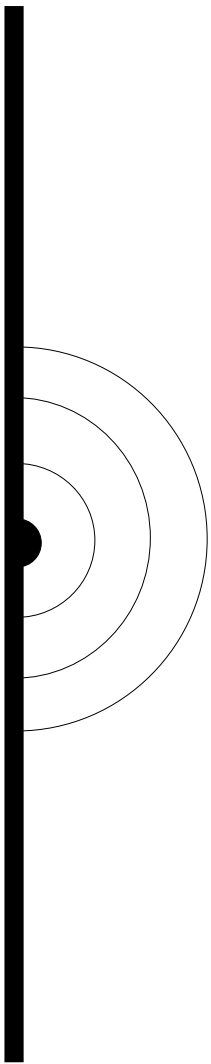


Com ondas

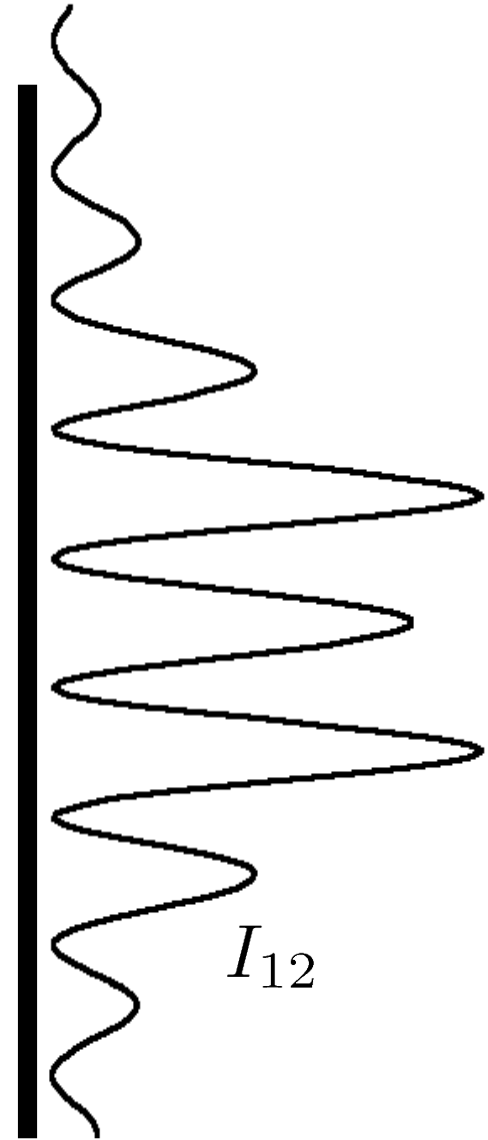
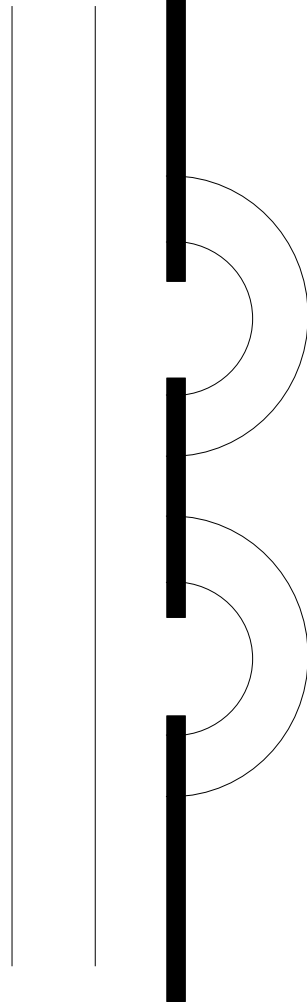
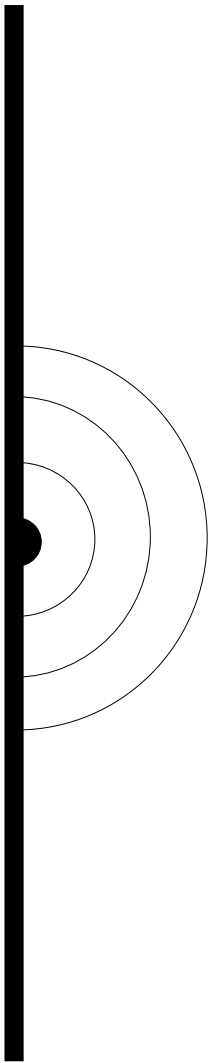


Intensidade $I = h^2$ quadrado da altura da onda

Com ondas



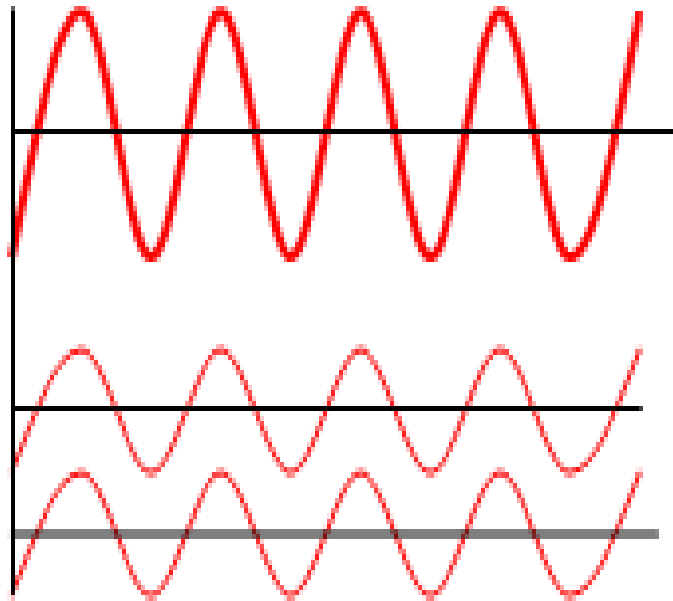
Com ondas



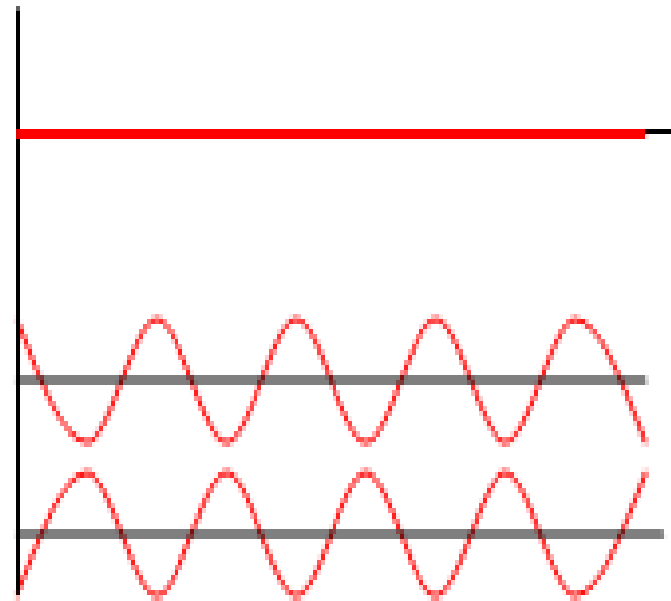
Interferência

$$I_{12} \neq I_1 + I_2$$

Interferência

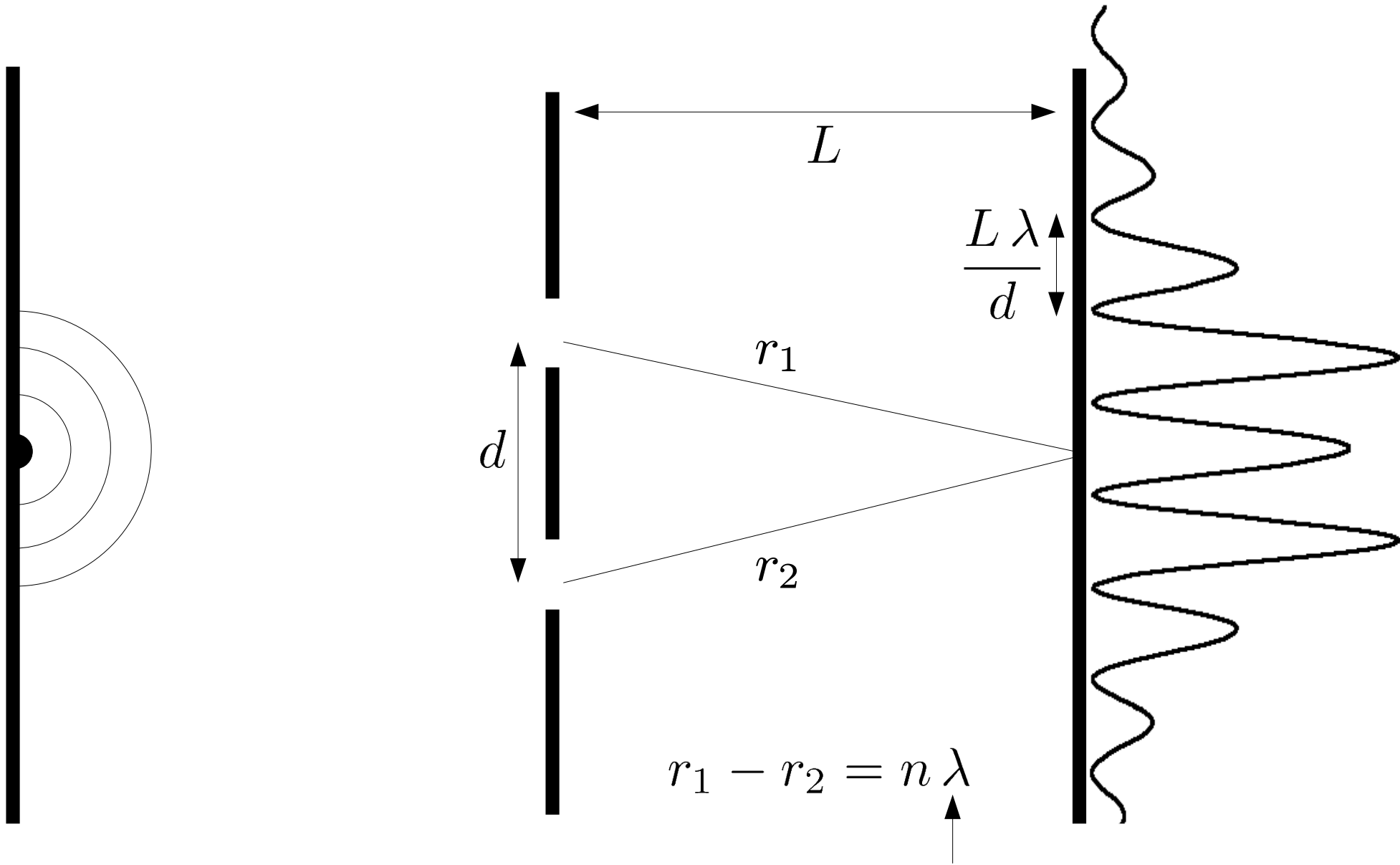


Constructiva



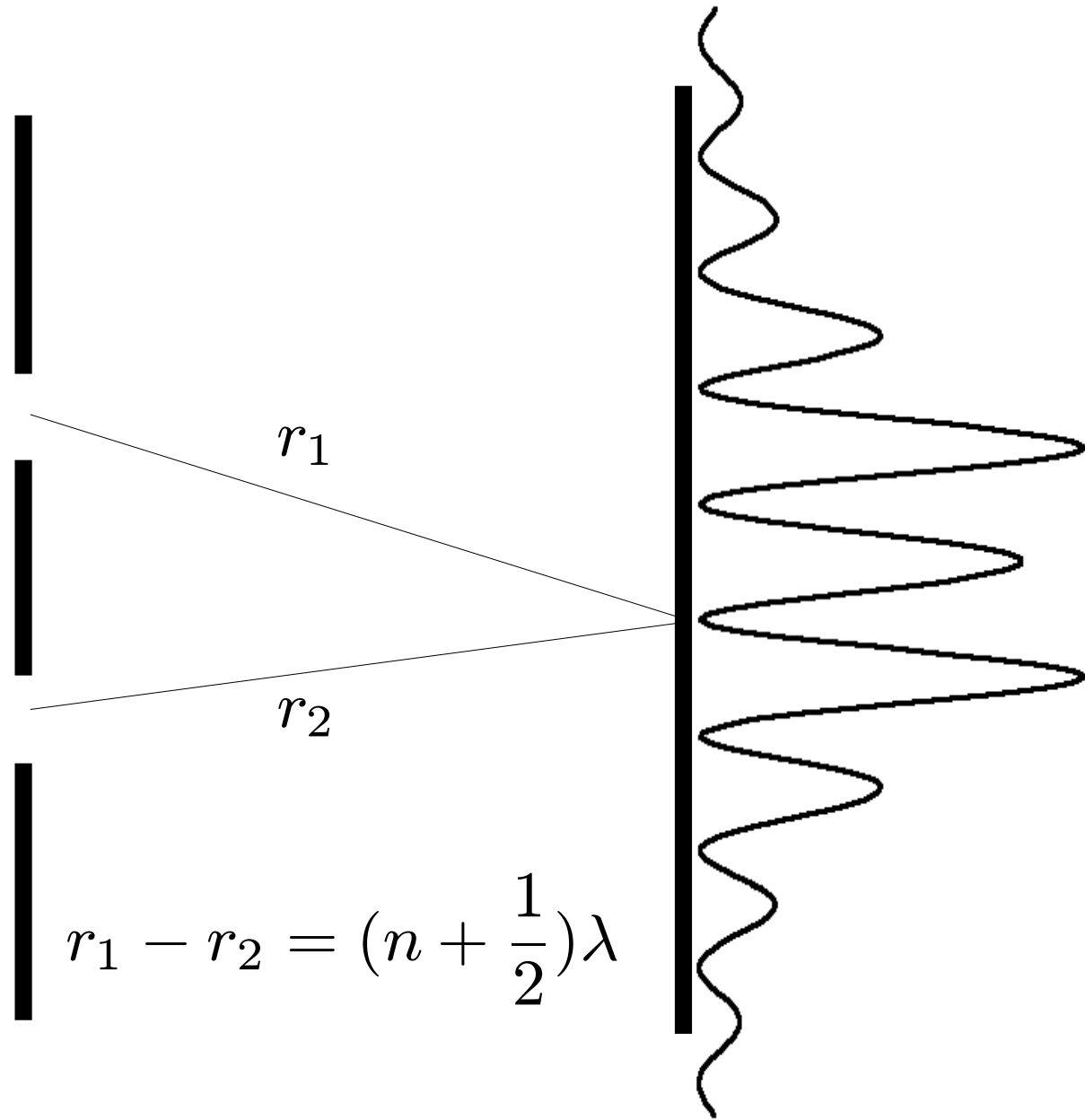
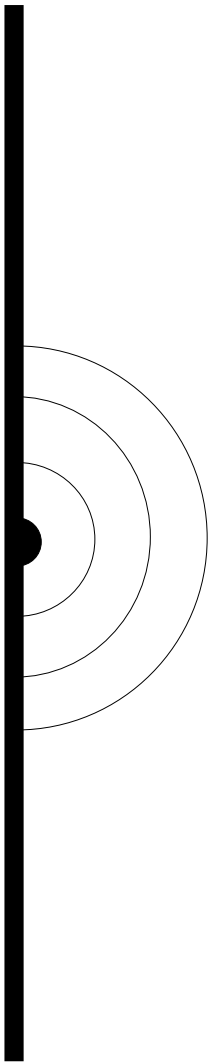
Destrutiva

Interferência construtiva



Comprimento de onda

Interferência destrutiva



Bolas

Ondas

Electrões

**Chegam em unidades
(quantum)**

SIM

NÃO

SIM

Interferem

NÃO

SIM

SIM

AVISO:

Os electrões comportam-se de forma muito diferente de tudo o que nós estamos habituados.

A nossa intuição está limitada à nossa experiência e não funciona bem com electrões.

Função de Onda

A função de onda ψ é a “onda do electrão”.

$$|\psi(x)|^2 = \text{Probabilidade de encontrar o electrão na posição } x$$

A equação que descreve a evolução temporal da função de onda é a **equação de Schrodinger**.

Comprimento de onda
(De Broglie)

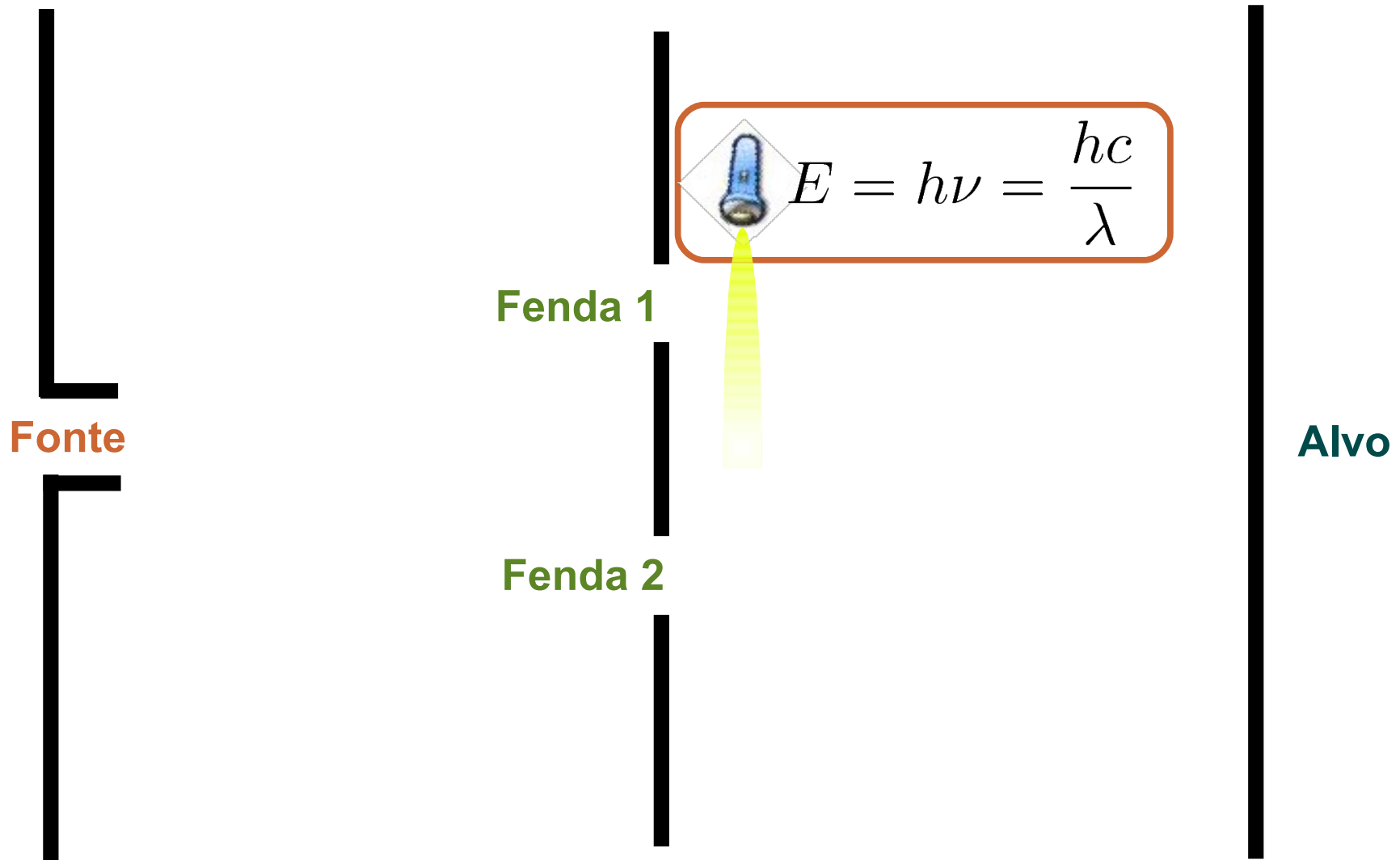
$$\lambda = \frac{h}{p}$$

Constante de Planck

Momento

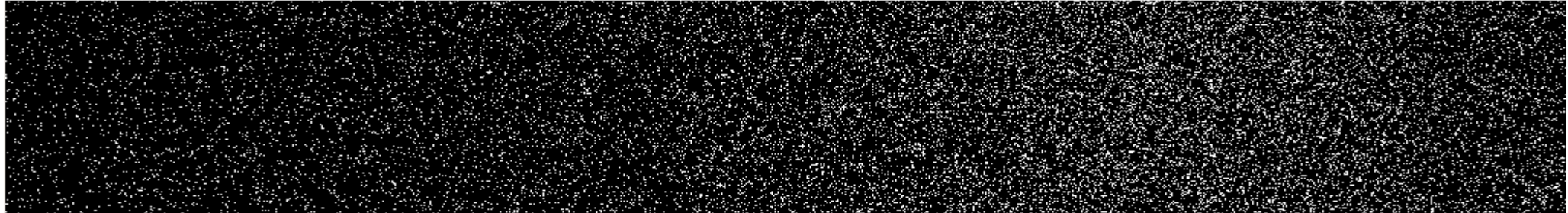
$$h = 6,6 \times 10^{-34} \text{ m}^2 \text{ Kg/s}$$

Por que fenda passou o electrão?

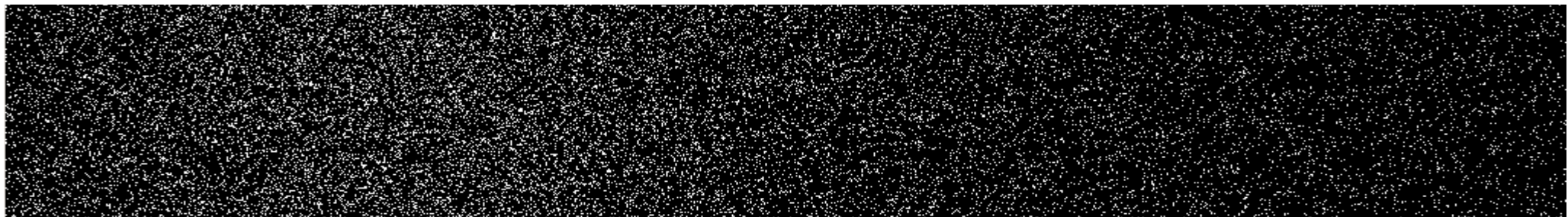


Colapso da função de onda

Medir por que fenda passa o electrão destrói o padrão de interferência



Apenas a fenda 1 aberta



Apenas a fenda 2 aberta



Ambas as fendas abertas

Aleatoriedade Fundamental

Por que fenda vai passar o próximo electrão?

- O electrão vai passar na fenda 1 com probabilidade $\frac{1}{2}$ e na fenda 2 com probabilidade $\frac{1}{2}$.

A existência do padrão de interferência implica que nem o electrão sabe por qual das fendas vai passar!

Sumário:

O estado do electrão é descrito pela função de onda ψ

$|\psi(x)|^2$ = Probabilidade de encontrar o electrão na posição x

Função de onda evolui de acordo com a equação de Schrodinger.

Quando observamos o electrão, a sua função de onda colapsa.

Energia $E = h\nu$

↑

Frequência

Momento $p = \frac{h}{\lambda}$

↙

Comprimento de onda