Erwin Schrödinger

The Quantum Pioneer

Prof. Ana Isabel Castillo

Setembro 2025

Erwin Schrödinger

The Quantum Pioneer

A Legacy in Quantum Mechanics

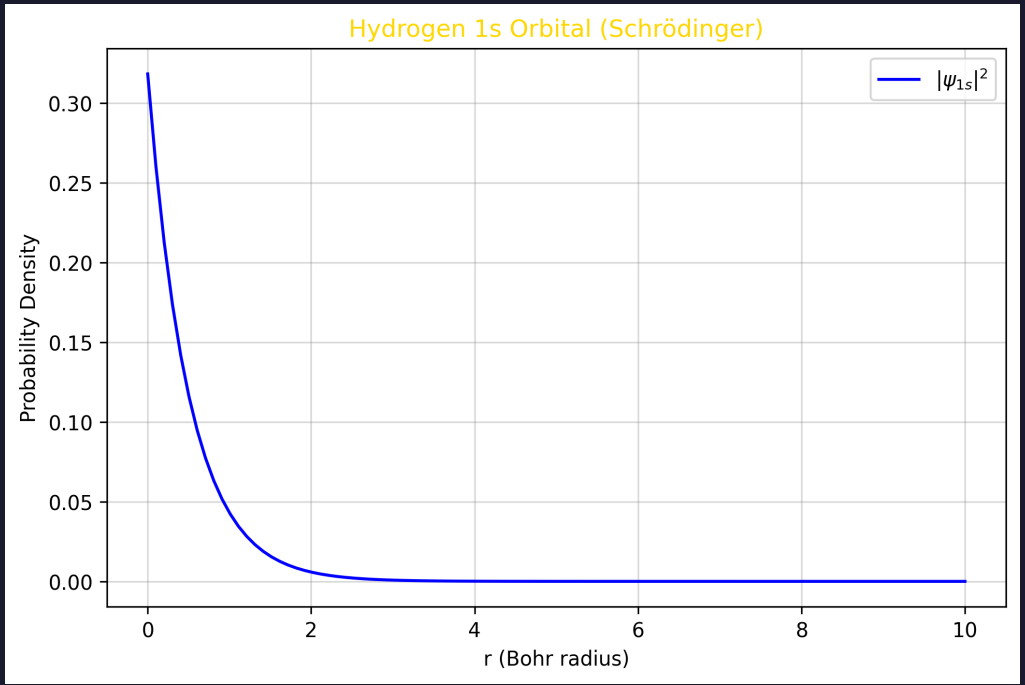
Austrian physicist (1887–1961), Nobel Prize in Physics (1933). His equation and thought experiment reshaped science, from atoms to biology.

The Schrödinger Equation

Core of Quantum Mechanics

$$i\hbar\frac{\partial\psi}{\partial t} = \hat{H}\psi, \qquad \hat{H}\psi = E\psi$$

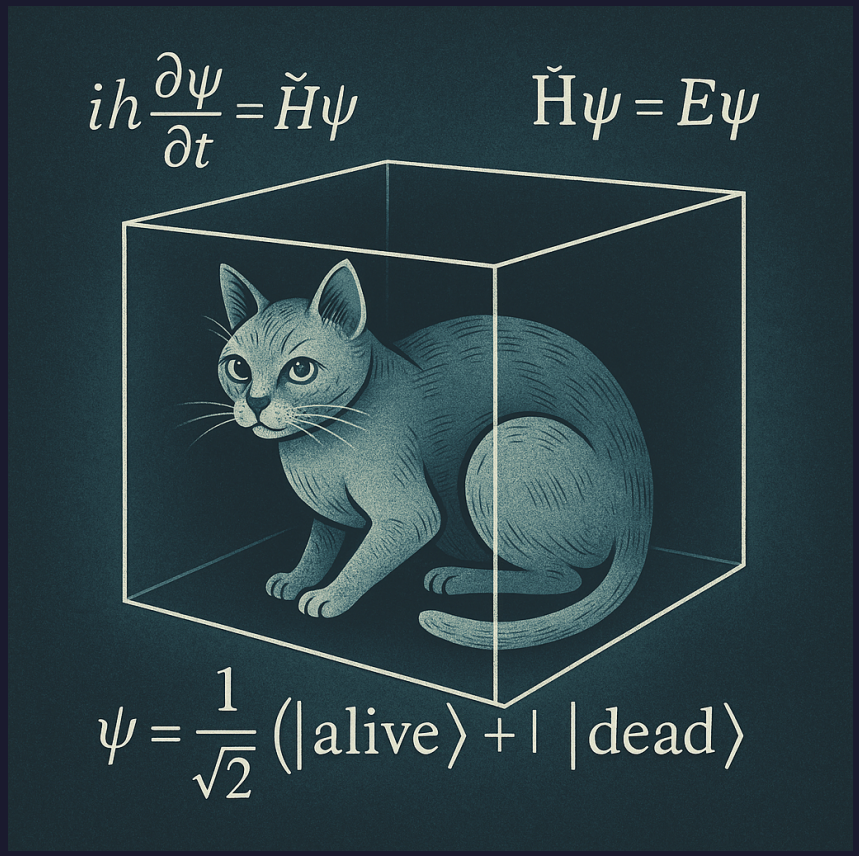
Describes the evolution of the wave function ψ, predicting quantum behavior (e.g., electron orbitals). Used in $> 50\%$ of modern quantum chemistry calculations [**?**].



Schrödinger's Cat

Superposition Paradox

A 1935 thought experiment: a cat in a box is both alive and dead until measured, challenging the Copenhagen interpretation. Shapes debates in quantum computing and philosophy [?].



Interdisciplinary Impact

Beyond Physics

- **What Is Life? (1944)**: Applied quantum ideas to biology, inspiring DNA discovery (Watson, Crick).
- **Other Works**: Statistical mechanics, quantum field theory, philosophy of consciousness.
- **Impact**: Bridged physics, biology, and philosophy [**?**].

Time-Independent Schrödinger: Exemplos

Equação em 1D

$$-\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V(x)\,\psi = E\,\psi, \qquad \int |\psi(x)|^2\,dx = 1$$

Poço Infinito $(0 < x < L)$

$$\psi_n(x) = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right), \qquad E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}, \quad n = 1, 2, \ldots$$

Estados quantizados: energias crescem com n^2.

Oscilador Harmônico

$$V(x) = \tfrac{1}{2}m\omega^2 x^2, \qquad E_n = \left(n + \tfrac{1}{2}\right)\hbar\omega$$

$$\psi_n(x) = \left(\frac{\alpha}{\pi}\right)^{1/4}\frac{1}{\sqrt{2^n n!}}\,H_n(\sqrt{\alpha}\,x)\,e^{-\alpha x^2/2}, \quad \alpha = \frac{m\omega}{\hbar}$$

Quantum Tunneling (barreira retangular)

Ideia

Para $E < V_0$ e barreira de largura a:

$$T \approx e^{-2\kappa a}, \qquad \kappa = \frac{\sqrt{2m\,(V_0 - E)}}{\hbar}.$$

Exemplo numérico (elétron)

$V_0 = 5\,\text{eV}$, $E = 3\,\text{eV}$, $a = 1\,\text{nm}$.

$$\kappa \approx 7.25 \times 10^9\ \text{m}^{-1}, \qquad T \approx e^{-2\kappa a} \approx e^{-14.5} \approx 5.1 \times 10^{-7}.$$

Mesmo com $E < V_0$, há chance (pequena) de atravessar a barreira.

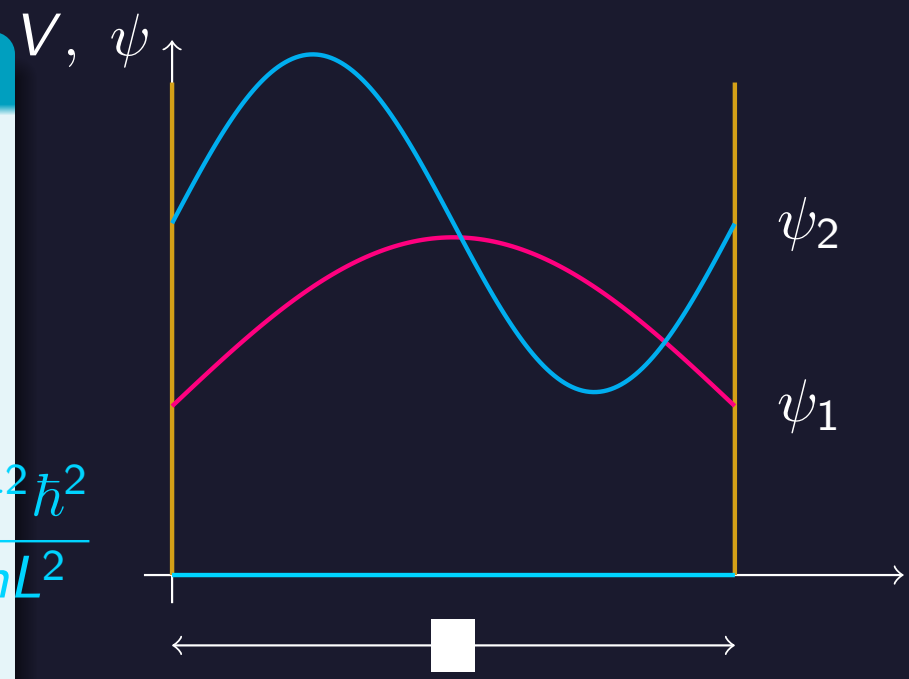
Time-Independent Schrödinger: Poço Infinito (0 ¡ x ¡ L)

Potencial e autostados

$$V(x) = \begin{cases} 0, & 0 < x < L \\ \infty, & \text{caso contrário} \end{cases}$$

$$\psi_n(x) = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right), \quad E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}$$

A energia é quantizada e cresce como n^2.



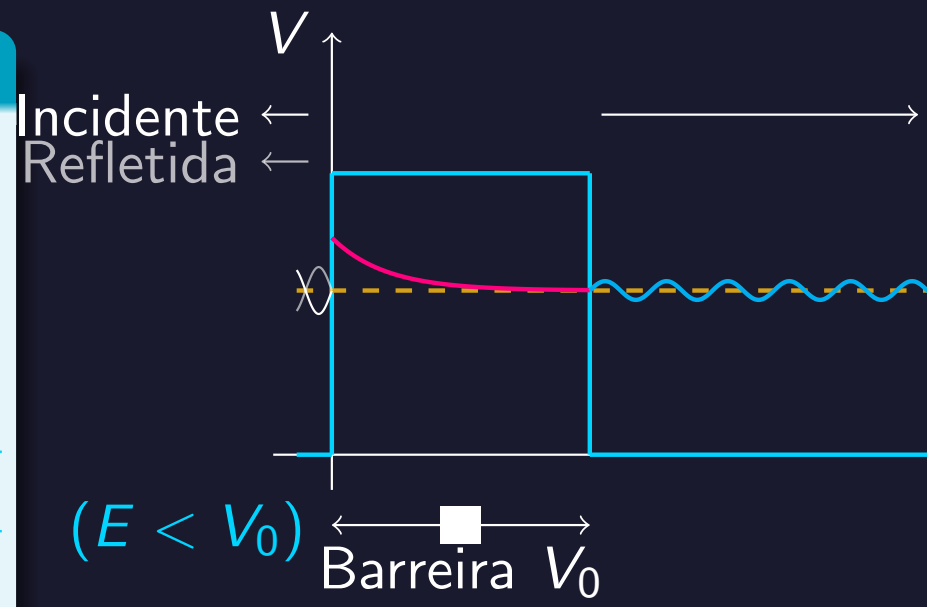
Quantum Tunneling: Barreira Retangular

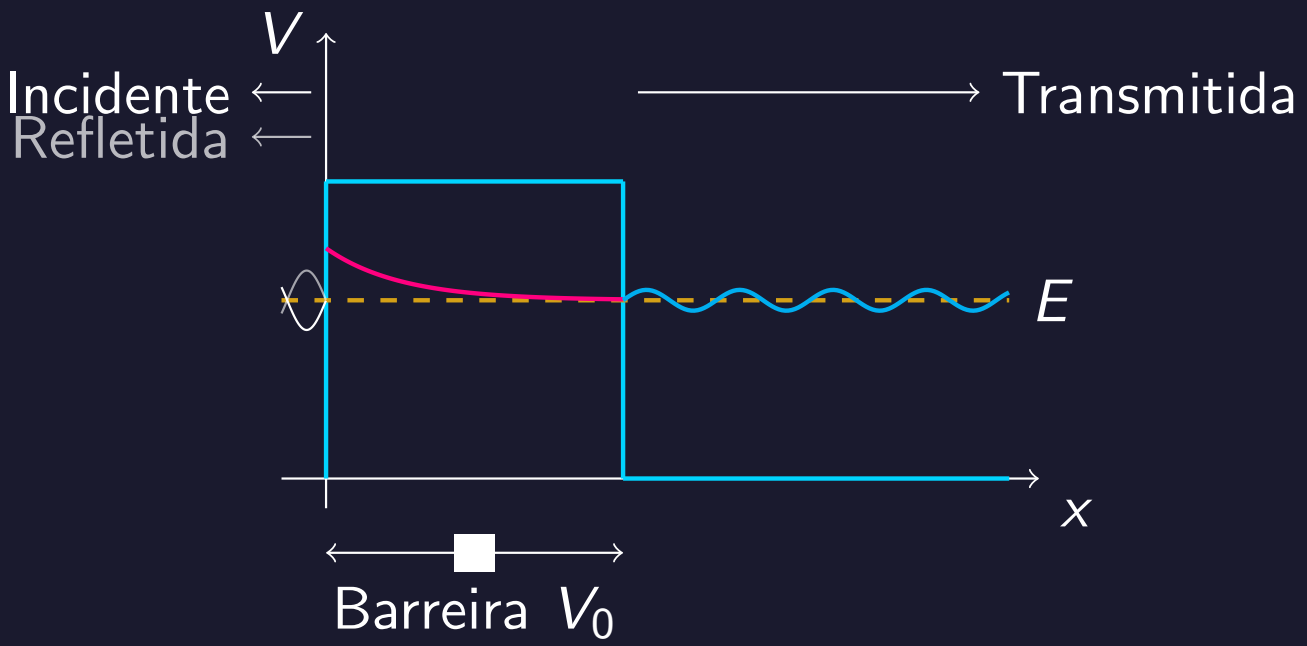
Potencial

$$V(x) = \begin{cases} 0, & x < 0 \\ V_0, & 0 \leq x \leq a \\ 0, & x > a \end{cases}$$

$$T \approx e^{-2\kappa a}, \qquad \kappa = \frac{\sqrt{2m(V_0 - E)}}{\hbar}$$

Mesmo com $E < V_0$, há probabilidade não nula de transmissão ($T > 0$).




V
Incidente
Refletida
Transmitida
E
x
Barreira V_0

Schrödinger's Legacy

A Scientific Revolution

- **Awards**: Nobel Prize 1933, Max Planck Medal 1937.
- **Influence**: Founded Dublin Institute for Advanced Studies; equation used in modern tech (e.g., semiconductors).
- **Legacy**: Unified mathematics, physics, and biology, inspiring generations.

References

- Schrödinger, E. (1926). An Undulatory Theory of the Mechanics of Atoms and Molecules. *Phys. Rev.*, 28(6), 1049–1070.
- Schrödinger, E. (1935). The Present Situation in Quantum Mechanics. *Naturwissenschaften*, 23, 807–812.
- Schrödinger, E. (1944). *What Is Life?* Cambridge University Press.

Conexão & Colaboração

- Abra issues no GitHub!
- Contato: anacp20@gmail.com
- https://github.com/IsabelCasPe/QuantDataScienceX