The postulates of quantum mechanics

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The Wave Function

The wavefunction: All dynamical information is contained in the wavefunction ψ for the system, which is a mathematical function found by solving the Schrödinger equation for the system. In one dimension:

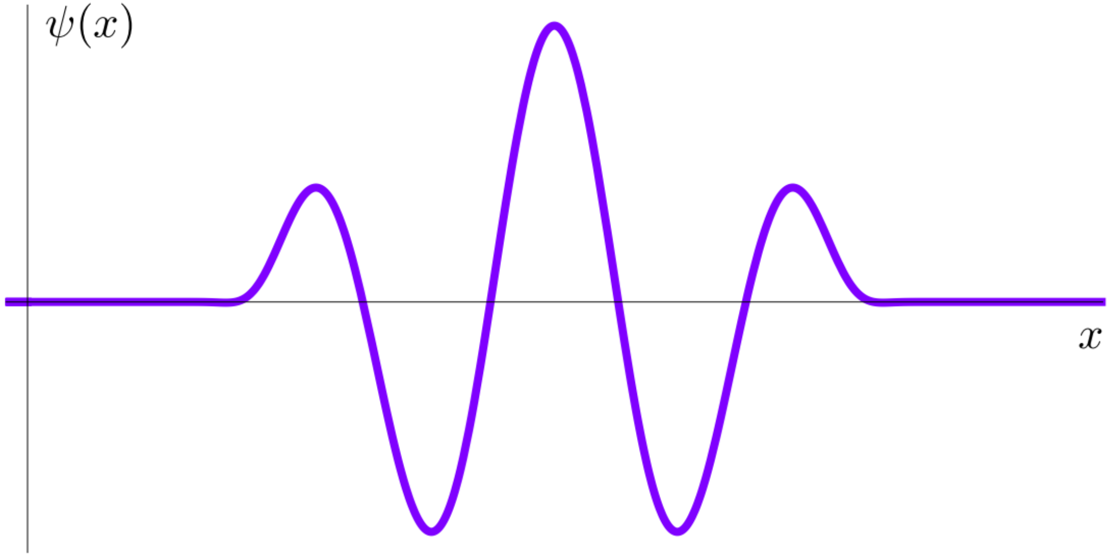
$$-\frac{\hbar^2}{2m}\frac{\mathrm{d}^2\psi}{\mathrm{d}x^2}+V(x)\psi=E\psi$$

The Wave Function

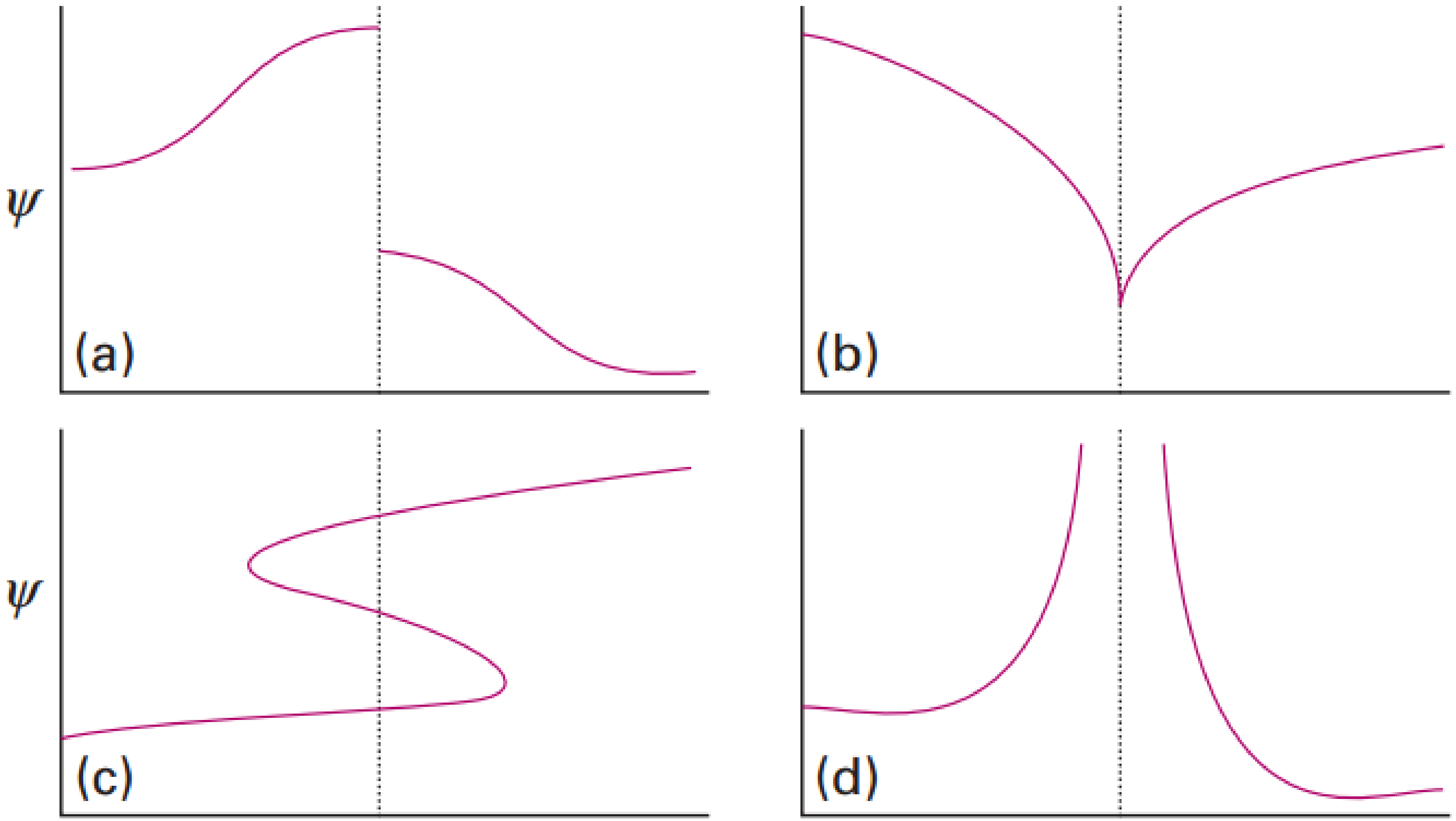
The Born interpretation: If the wavefunction of a particle has the value ψ at some point $\boldsymbol{r}$, then the probability of finding the particle in an infinitesimal volume $\mathrm{d}\tau = \mathrm{d}x\mathrm{d}y\mathrm{d}z$ at that point is proportional to $|\psi|^2\mathrm{d}\tau$.

The Wave Function

Acceptable wavefunctions: An acceptable wavefunction must be single-valued, continuous, not infinite over a finite region of space, and have a continuous slope.



The Wave Function



Operators in QM

Observables: Observables, Ω, are represented by operators, $\hat{\Omega}$, built from the following position and momentum operators:

$$\hat{x} = x \times \qquad \hat{p}_x = \frac{\hbar}{\mathrm{i}} \frac{\mathrm{d}}{\mathrm{d}x}$$

Uncertainty Principle

The Heisenberg uncertainty relation: It is impossible to specify simultaneously, with arbitrary precision, both the momentum and the position of a particle and, more generally, any pair of observables with operators that do not commute.

$$\Delta x \, \Delta p_x \geq \frac{\hbar}{2}$$

The Postulates of QM

Postulate 1. The state of a quantum-mechanical system is completely specified by a wavefunction Ψ that depends on the coordinates and time. The square of this function $\Psi^*\Psi$ gives the probability density for finding the system with a specified set of coordinate values.

The wavefunction must be single-valued, finite and continuous.	$\int \Psi^*\Psi \, d\tau = 1$

The Postulates of QM

Postulate 2. Every observable in quantum mechanics is represented by a linear, hermitian operator.

A linear operator is one which satisfies the identity $\hat{A}(c_1\psi_1 + c_2\psi_2) = c_1\hat{A}\psi_1 + c_2\hat{A}\psi_2$

The Postulates of QM

Postulate 3. In any measurement of an observable A, associated with an operator $\hat{A}$, the only possible results are the eigenvalues a_n, which satisfy an eigenvalue equation

$$\hat{A}\psi_n = a_n \psi_n$$

The Postulates of QM

Postulate 4. For a system in a state described by a normalized wave function Ψ , the average or expectation value of the observable corresponding to A is given by

$$\langle A \rangle = \int \Psi^* \, \hat{A} \, \Psi \, d\tau$$

The Postulates of QM

Postulate 5. The wavefunction of a system evolves in time in accordance with the time-dependent Schrödinger equation

$$i\hbar \frac{\partial \Psi}{\partial t} = \hat{H}\,\Psi$$

$$\boxed{\hat{H} = -\frac{\hbar^2}{2m}\frac{\mathrm{d}^2}{\mathrm{d}x^2} + V(x)}$$

In 1D for a particle moving in a potential *V*(*x*)

Thank You

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