Quantum Mechanics

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1) The wavefunction defines the state of a QM system completely:

$$\psi(x)$$

The **probability** that a particle lies in an interval dx :

$$\psi^*(x)\psi(x)dx$$

The **wavefunction** is normalized:

$$\int \psi^*(x)\psi(x)dx = 1$$

Properties of the wavefunction: it only has one value at a given point in space and time, it is finite and continuous at all points, as are its first and second derivatives with respect to distance.

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2) Every classical observable has a QM linear, Hermitian operator:

Property	Symbol	Operator
Position	$\hat{X}$	multiply by x
Momentum	$\hat{P}_x$	$-i\hbar\frac{\partial}{\partial x}$
Kinetic energy	$\hat{K}$	$-\frac{\hbar^2}{2m}\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}\right)=-\frac{\hbar^2}{2m}\nabla^2$
Potential energy	$\hat{V}(\hat{x},\hat{y},\hat{z})$	multiply by $V(x,y,z)$
Total energy	$\hat{H}$	$-\frac{\hbar^2}{2m}\nabla^2+V(x,y,z)$
Angular momentum	$\hat{L}_x$	$-i\hbar\left(y\frac{\partial}{\partial z}-z\frac{\partial}{\partial y}\right)$

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3) Observables associated with an operator are eigenvalues of the wavefunction.

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

The **time-independent Schrödinger equation** is a special case:

$$\hat{H}\psi_n = E_n \psi_n$$

4) The average value of an observable is defined as:

$$\langle a \rangle = \int \psi^* \hat{A} \psi dx$$

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5) The wavefunction is solution to the **time-dependent Schrödinger equation:**

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

Typically, we can separate the spatial and temporal:

$$\Psi(x,t) = \psi(x)f(t)$$

Most wavefunctions of interest are stationary-state solutions:

$$\Psi_n(x,t) = \psi_n(x)e^{-iE_nt/\hbar}$$

In this course we focus only on solving the time-independent equation:

$$\hat{H}\psi(x) = E\psi(x)$$

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References:

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