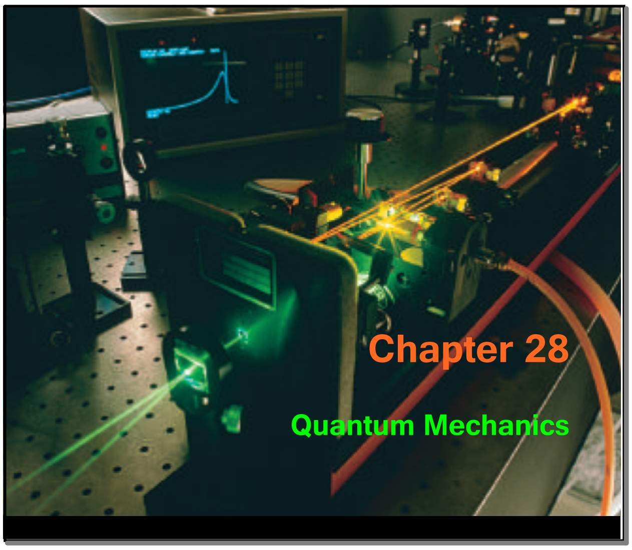


Probability and Quantum Mechanics

"CONSERVATION OF PROBABILITY"

Probability and Quantum Mechanics
The "Monte Hall" Problem

DOOR #1 DOOR #2 DOOR #3

The Electron Cloud

Probability Functions: Defining and Using Them

The electron in a box

The electron in a box: the "reality"

Probability Conservation Equation

Start from the probability and differentiate with respect to time.

$$\frac{\partial P(x,t)}{\partial t} = \frac{\partial}{\partial t}\left(\psi^*(x,t)\psi(x,t)\right) = \left[\frac{\partial \psi^*}{\partial t}\psi - \psi^*\frac{\partial \psi}{\partial t}\right]$$

Use the Schrödinger Equation

$$\frac{-\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} + V(x)\psi = i\hbar\frac{\partial \psi}{\partial t}$$

and its complex conjugate

$$\frac{-\hbar^2}{2m}\frac{\partial^2\psi^*}{\partial x^2} + V(x)\psi^* = -i\hbar\frac{\partial \psi^*}{\partial t}.$$

(We assume $V(x)$ is real. Imaginary potentials do cause probability not to be conserved.)

Now we need to plug those equations in.

$$\frac{\partial P(x,t)}{\partial t} = \frac{1}{i\hbar}\left[\frac{\hbar^2}{2m}\frac{\partial^2\psi^*}{\partial x^2}\psi - V(x)\psi^*\psi + \frac{-\hbar^2}{2m}\psi^*\frac{\partial^2\psi}{\partial x^2} + V(x)\psi^*\psi\right]$$

$$= \frac{1}{i\hbar}\frac{\hbar^2}{2m}\left[\frac{\partial^2\psi^*}{\partial x^2}\psi - \psi^*\frac{\partial^2\psi}{\partial x^2}\right] = \frac{\hbar}{2mi}\frac{\partial}{\partial x}\left[\frac{\partial \psi^*}{\partial x}\psi - \psi^*\frac{\partial \psi}{\partial x}\right]$$

This is the usual conservation equation $j(x,t)$ if is identified as the probability current.

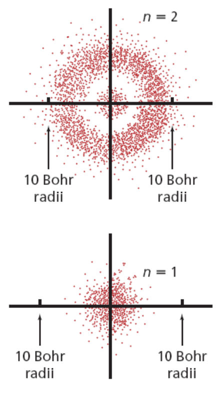
$$\frac{\partial P(x,t)}{\partial t} + \frac{\partial j(x,t)}{\partial x} = 0$$

$$j(x,t) = \frac{\hbar}{2mi}\left[\psi^*\frac{\partial \psi}{\partial x} - \frac{\partial \psi^*}{\partial x}\psi\right]$$

The Wave Function:

Probability of Electron Location

The Schrödinger Wave Equation



Why do we need "orbitals" to describe the location of electrons? Because electrons are constantly in motion!

The propeller example:

The propeller at rest


The propeller in motion

The Heisenberg Uncertainty Principle

Example 28-1, pg 792

An electron moves in a straight line with a constant speed 1.10×10^6 m/s which has been measured to a precision of 0.10 percent. What is the maximum precision with which its position could be simultaneously measured?

Example 28-2, pg 792

What is the uncertainty in position imposed by the uncertainty principle on a 150 g baseball thrown at 93 mph $\pm$ 2 mph ? (42 m/s $\pm$ 1 m/s)