LECTURE # 12, FRI., 10-28

*) $$\boxed{\lambda = \frac{h}{mv} = \frac{h}{p}}$$

→ DE BROGLIE PROPOSED THAT THIS RELATION SHOULD HOLD -- not only for electrons, but also -- FOR <u>ALL</u> PARTICLES, AND FOR LIGHT... ! WAVES!

→ A typical e velocity in H-atom is about 1.0×10^{6} m/s. This implies a (de Broglie) wavelength of about 7 Å ($\gg a_0 \approx 0.5$ Å $\approx$ size of atom)

→ A baseball, with a speed of 70 mi/hr ($\leftrightarrow \approx 30$ m/s) and mass of ⅓ lb ($\leftrightarrow \approx 0.15$ kg), on the other hand, has a de Broglie wavelength of about 1.5×10^{-24} Å ($\ll \cdots \ll 10^{9}$ Å $\approx$ size of ball $\ll 10^{12}$ Å $\approx$ size of field)

∴ We don't see the wave-like properties of baseballs (or of any other macroscopic -- e.g., visible to the naked eye -- objects)

[Similarly, we will learn -- from "particle in a box" ~~model~~, say, that energy differences between quantized energies of baseballs (and other macroscopic systems) are far too small to see (measure)!]

Davisson-Germer experiment, 1927

NOTE: The wavelength properties of electrons are especially apparent, and useful, in the instance of determining crystal structures (particularly, of their surfaces) via e-diffraction (e.g., LEED)

★ THE SCHRÖDINGER EQUATION

→ According to CLASSICAL MECHANICS (CM), a complete description of a system (e.g., speeding bullet, falling apple, launched rocket spaceship, etc.) is given by the "path" (or "trajectory") $x(t)$

- And $x(t)$ is obtained by solving Newton's equation, $F = ma$, or

DON'T NEED TO KNOW THIS EQUATION!

$$F = m\frac{d^2x(t)}{dt^2} = -\frac{dV(x)}{dx}$$

→ According to QUANTUM MECHANICS (QM), a complete description of a system is given by its wavefunction, $\psi(x)$

- And $\psi(x)$ is obtained by solving Schrödinger's equation

DON'T NEED TO KNOW THIS EQUATION!

$$V(x)\,\psi(x) - \frac{h^2}{8\pi^2 m}\frac{d^2V(x)}{dx^2} = E\,\psi(x)$$

where E is the system's energy

- It turns out that solutions exist only for special, discrete, values of E

E.g., for perfect spring, with $V(x) = \frac{1}{2}kx^2$, solutions exist only for

$$E = E_n^s = (n+\tfrac{1}{2})h\sqrt{\frac{k}{m}}, \quad n = 0, 1, 2, \ldots$$

And for e in H-atom, with $V(r) = -\frac{e^2}{4\pi\epsilon_0 r}$, solutions exist only for

$$E = E_n^H = -\frac{R}{n^2}, \quad n = 1, 2, \ldots$$

Etc.