Ch. 37 - Early quantum theory + Ch. 38 - Modern quantum theory

- Problems in classical physics (discrepancies b/w data and predictions):
  - Blackbody radiation
  - Photoelectric effect
  - Lines in atomic spectra

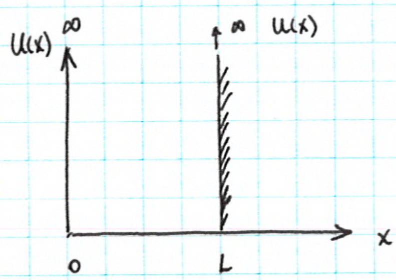
- New concepts / models of atom
  - Photon : $E = hf = \frac{hc}{\lambda}$ (h ↑ Planck's constant)
  - Atomic "nucleus" : protons, neutrons
  - Bohr model (for hydrogen) :
    - electron orbiting around proton
    - only force between them : Coulomb ("electric") force
    - orbits are discrete ("quantized") → stationary states
    - transitions b/w states : photon with energy $= \Delta E = E_f - E_i = hf = \frac{hc}{\lambda}$
    - energies of states $E_n = \frac{-13.6}{n^2}$ eV , $n = 1, 2, 3 \ldots$
    - "$mvr = n\hbar$"

- Problems with Bohr model :
  - no explanation for "$mvr = n\hbar$" → "matter waves" : $\lambda = \frac{h}{p}$
  - no good for atoms with $N_{e^-} > 1$ → Schrödinger's equation, wavefunctions, etc. indeterminism (HUP)

- Schrödinger equation: $\frac{d^2\psi}{dx^2} = -\frac{2m}{\hbar^2}(E - U)\psi$
  - ψ : "wavefunction" of particle.
  - E : total energy of particle, TBD.
  - U : potential energy function, given.
  - → solve for ψ, E : know everything possible about particle.

$|\psi(x)|^2$ → probability of finding particle at x.

- Example: particle in 1-D infinite box



$$\begin{cases} \psi_n = A \sin \frac{n\pi x}{L}, & n = 1, 2, 3 \ldots \\ E_n = \frac{n^2 h^2}{8mL^2} \end{cases}$$

- Example: hydrogen atom, $U = -\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$
  - Use 3D Schrödinger equation → ψ's and E's
  - ground state $\psi(r) = Ae^{-r/a_0}$
  - electron most likely to be found at Bohr orbits → but can be found elsewhere; "orbitals".

- Heisenberg's Uncertainty Principle
  - $\Delta x \cdot \Delta p_x \geq \frac{h}{2\pi}$
  - loss of determinism / causality → new view of reality.