Lecture 3, Jan 13, 2023

The Hydrogen Atom

- Recall:
  - Properties of the hydrogen atom indicated quantum behaviour – Rydberg's equation
  - Bohr introduced a quantization condition that explained the Hydrogen spectral lines
  - de Broglie proposed that matter has wavelike properties
  - Schrödinger then came up with the wave equation that explained Bohr's quantization condition
  - To solve the hydrogen atom, we take it to spherical coordinates and separate $\Psi(r, \theta, \phi) = R(r)\Theta(\theta)\Phi(\phi)$
- Summary of the Hydrogen solution:
  - $\Psi(r, \theta, \phi) + R_n(r)\Theta_{lm}(\theta)\Phi_m(\Phi)$
  - $n = 1, 2, 3, \cdots$
  - $E = -\frac{E_R}{n^2}$
  - $l = 0, 1, 2, \cdots, n - 1$
  - $m = 0, \pm 1, \pm 2, \cdots, \pm l$
  - The ground state is $n = 1, l = 0, m = 0$
  - Total angular momentum is $L = \sqrt{l(l+1)}\hbar$; $L_z = m\hbar$ is quantized just like Bohr assumed
    - * Think about a vector of length $L = \sqrt{l(l+1)}$ being projected onto the z axis
    - * l controls the total angular momentum; m controls how much of it is in the z axis