Electronic States of Matter

**Type of Matter:**

- Atoms (H as prototype)
  
  \[ V(r) = V_1(r - R_1) + V_2(r - R_2) \]

- Molecules (H₂ as prototype)
  
  Use the linear combination of atomic orbitals (LCAO)

- Solids (1-D chain as prototype)
  
  \[ V(r) = \sum_n V(r - R_n) \]

**Energy Spectrum:**

\[ E_n = -\frac{13.6}{n^2} \text{ eV} \]

**Excitations:**

- antibonding orbital
- bonding orbital

**Spherical Harmonics**

H atom \( \psi \)'s:

\[ \psi_{nm}(r, \theta, \phi) = f_{nl}(r) Y_{lm}(\theta, \phi) e^{-\frac{nr}{a_0}} \]

\[ f_{nl}(r) \] polynomial