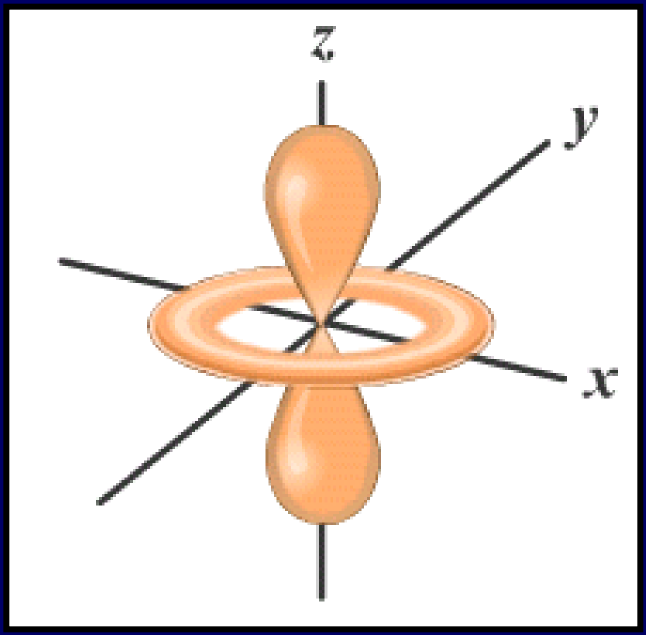
Electrons in Atoms

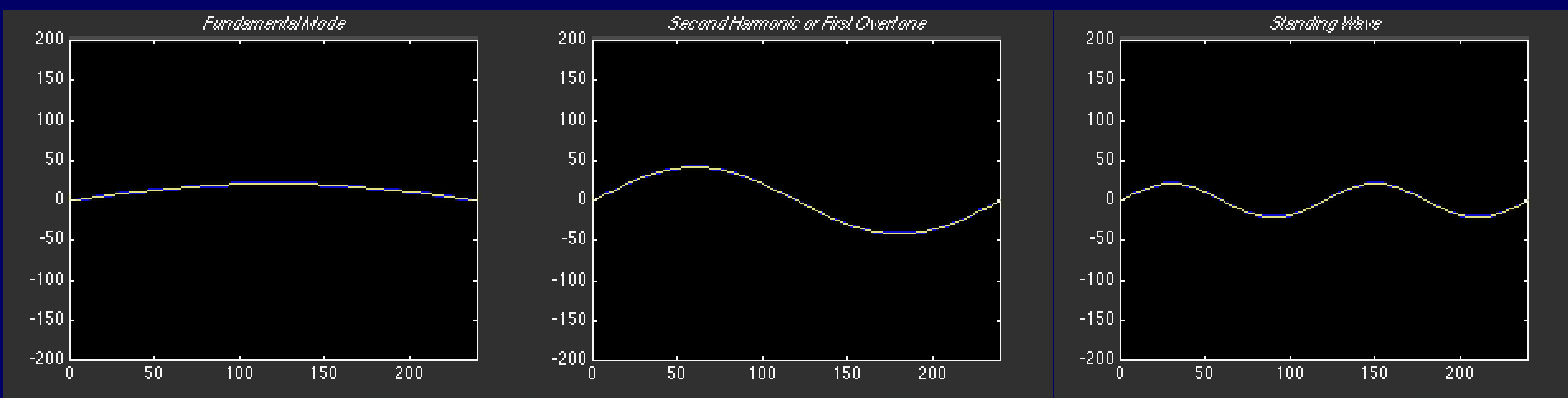


III. Quantum Model of the Atom

Electrons as Waves

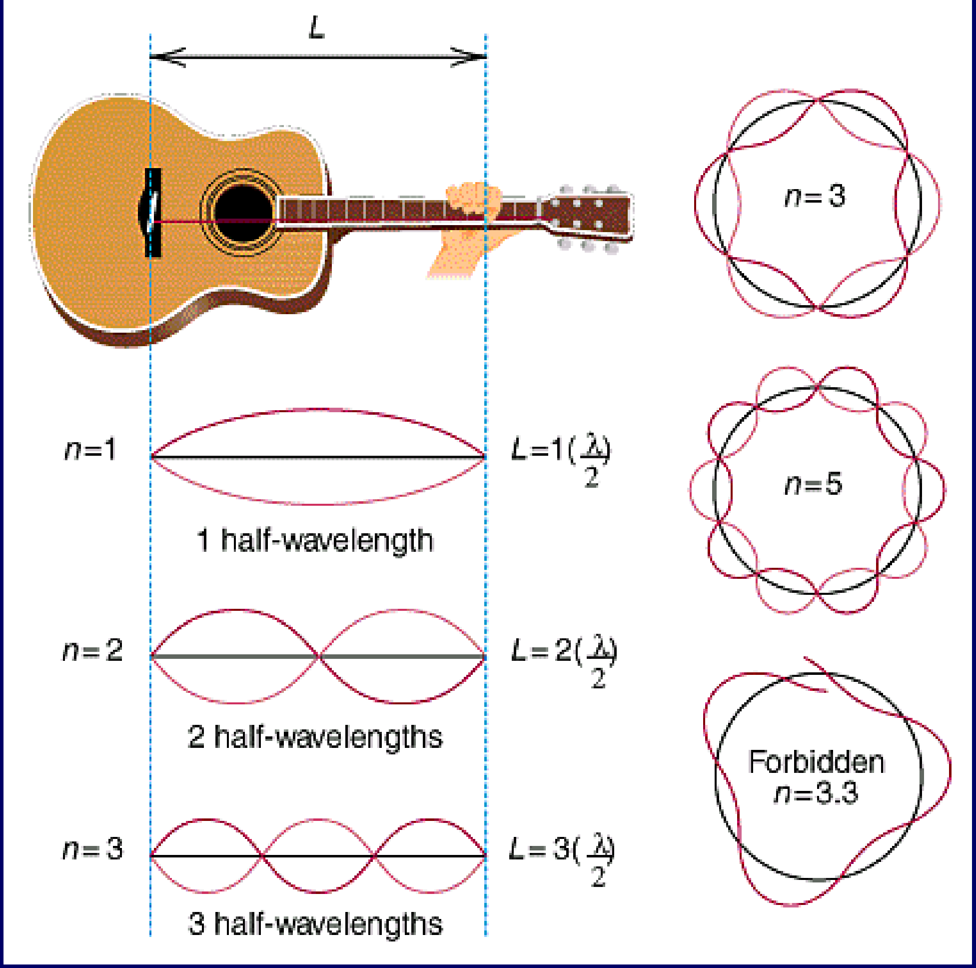
- **Louis de Broglie** (1924)
  - Applied wave-particle theory to e^-
  - e^- exhibit wave properties

QUANTIZED WAVELENGTHS



Electrons as Waves

QUANTIZED WAVELENGTHS



Electrons as Waves

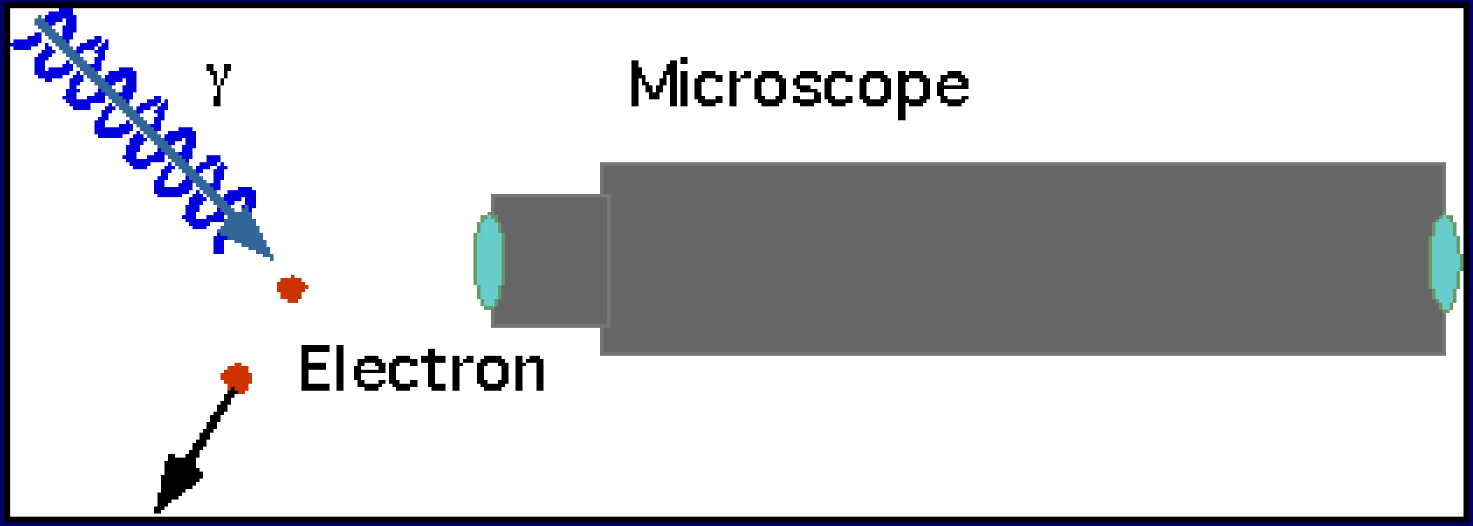
EVIDENCE: DIFFRACTION PATTERNS

VISIBLE LIGHT

ELECTRONS

Quantum Mechanics

- **Heisenberg Uncertainty Principle**
  - Impossible to know both the velocity and position of an electron at the same time



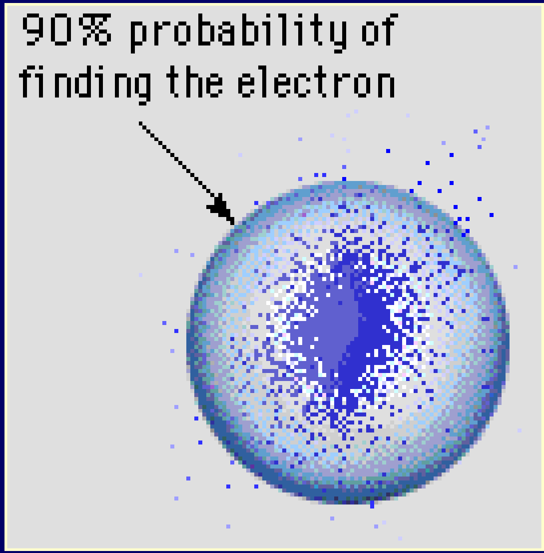
Quantum Mechanics

- **Schrödinger Wave Equation** (1926)
  - finite # of solutions ⇒ quantized energy levels
  - defines probability of finding an e^-

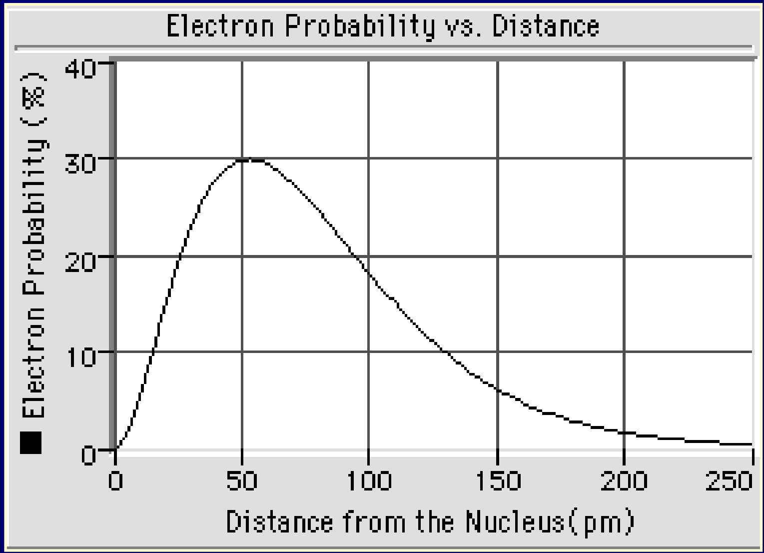
$$\Psi_{1s} = \frac{1}{\sqrt{\pi}}\left(\frac{Z}{a_0}\right)^{3/2} e^{-\sigma}$$

Quantum Mechanics

- **Orbital** (“electron cloud”)
  - Region in space where there is 90% probability of finding an e^-



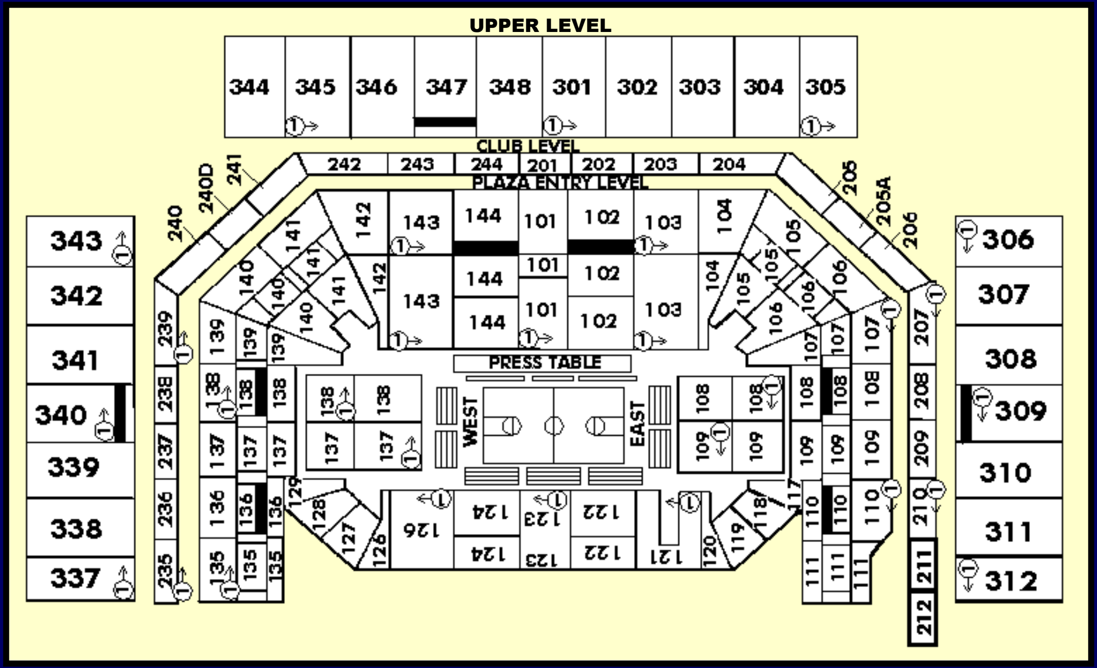
Orbital



Radial Distribution Curve

Quantum Numbers

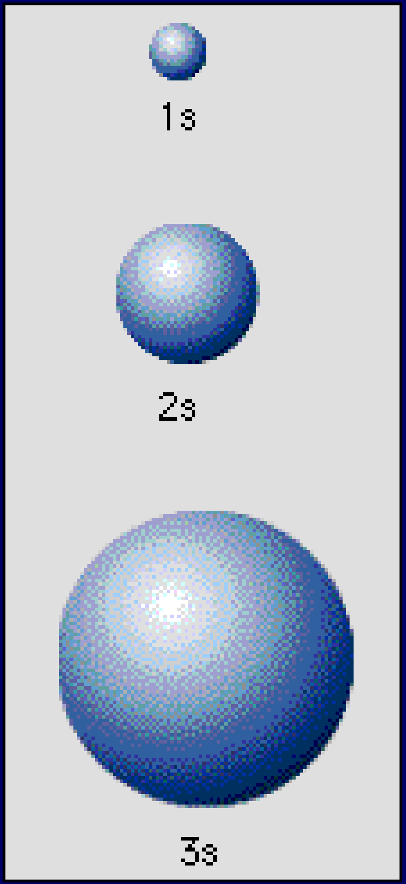
- **Four Quantum Numbers:**
  - Specify the “address” of each electron in an atom



Quantum Numbers

1. Principal Quantum Number (*n*)

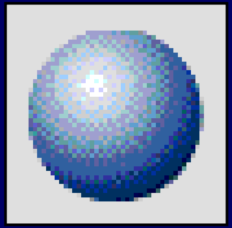
- Energy level
- Size of the orbital
- n^2 = # of orbitals in the energy level
- n = 1,2,3,…

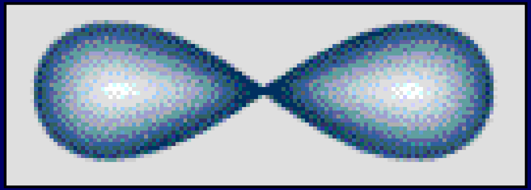


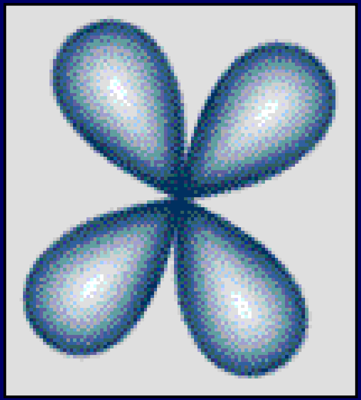
Quantum Numbers

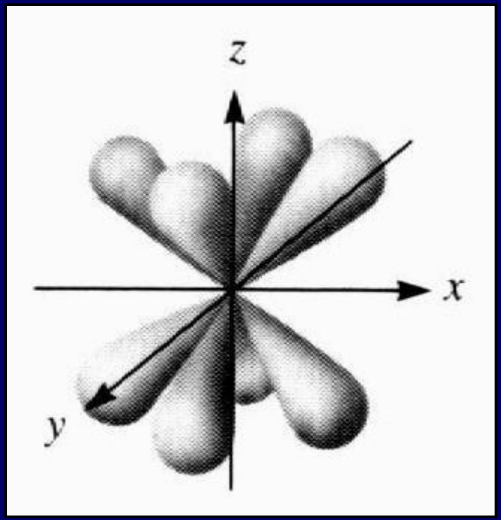
2. Angular Momentum Quantum # (*l*)

- Energy sublevel
- Shape of the orbital
- l = 0,1,2,… (n-1)



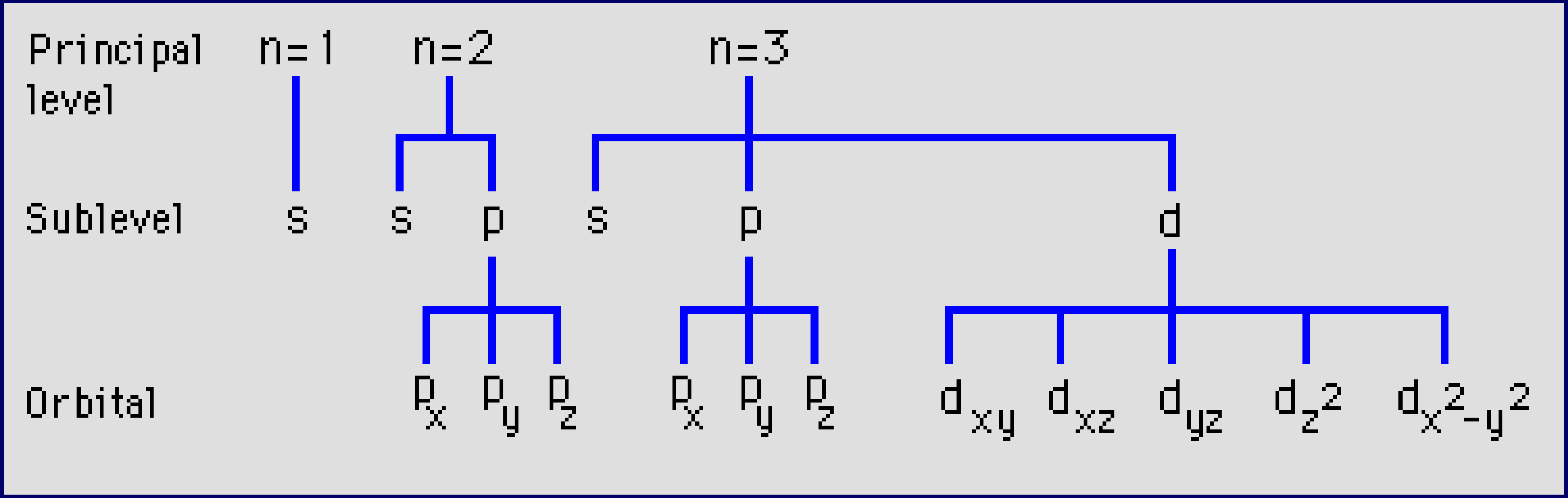






S=0 P=1 d=2 f =3

Quantum Numbers

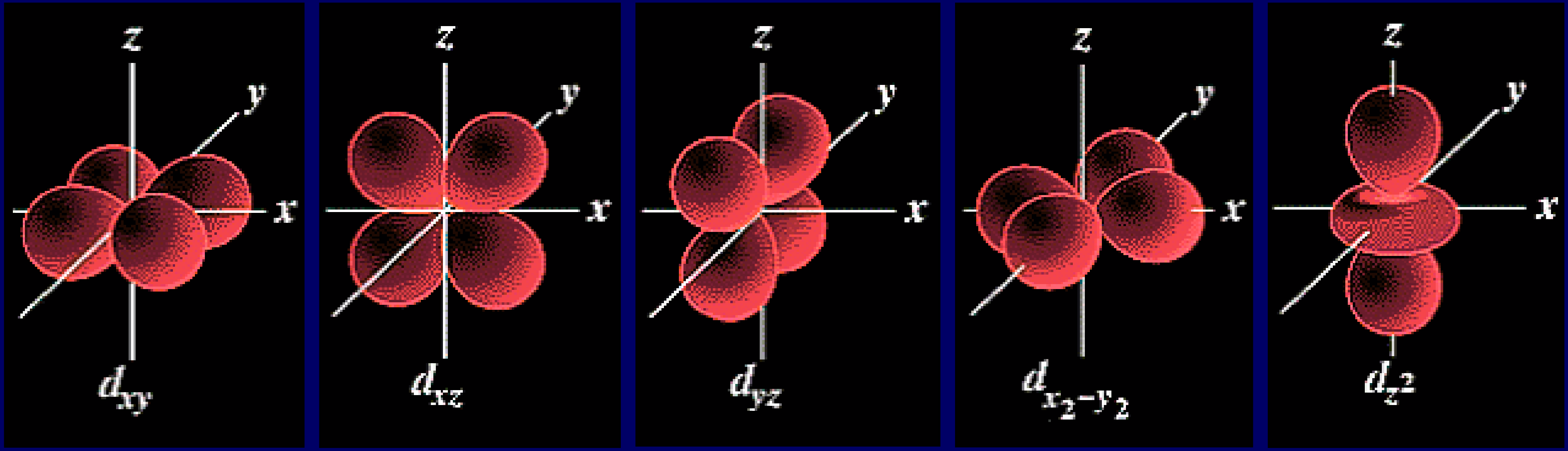


- n = # of sublevels per level
- n^2 = # of orbitals per level
- Sublevel sets: **1**s, **3**p, **5**d, **7**f

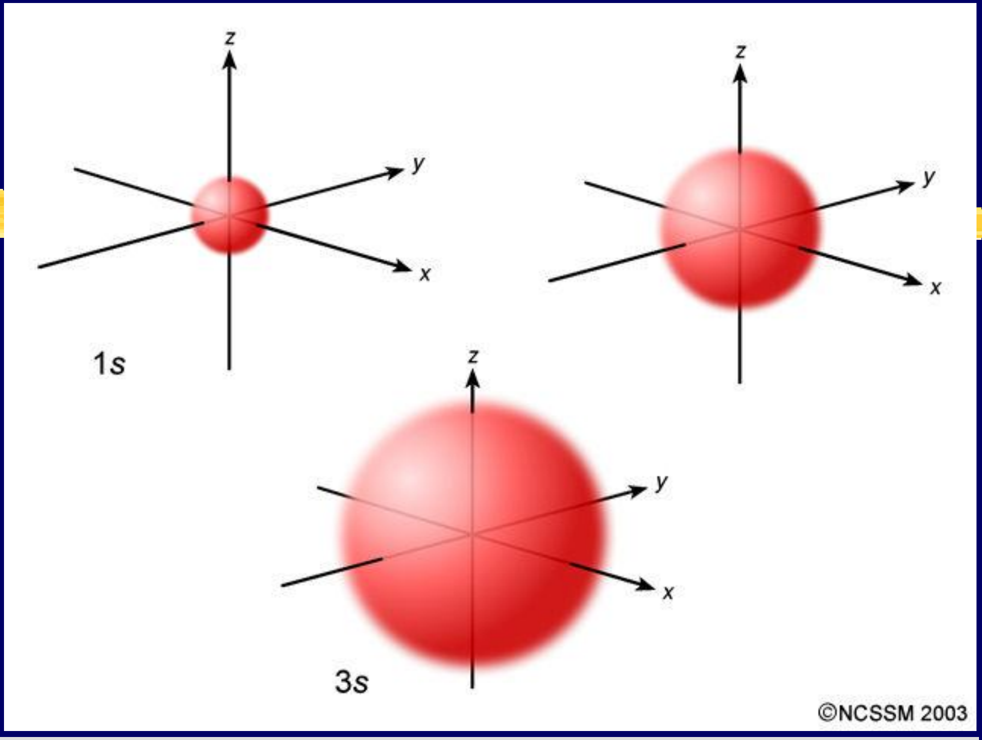
Quantum Numbers

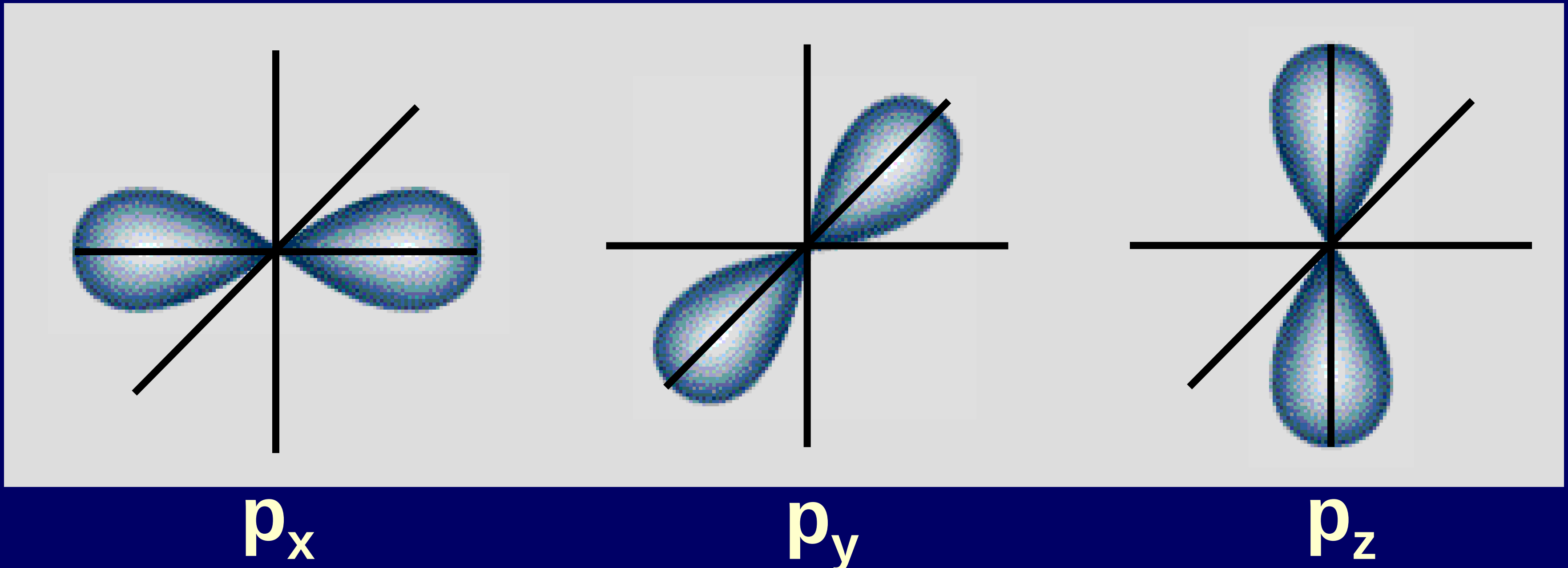
3. Magnetic Quantum Number (m_l)

- Orientation of orbital
- Specifies the exact orbital within each sublevel
- $m_l = -l \rightarrow +l$



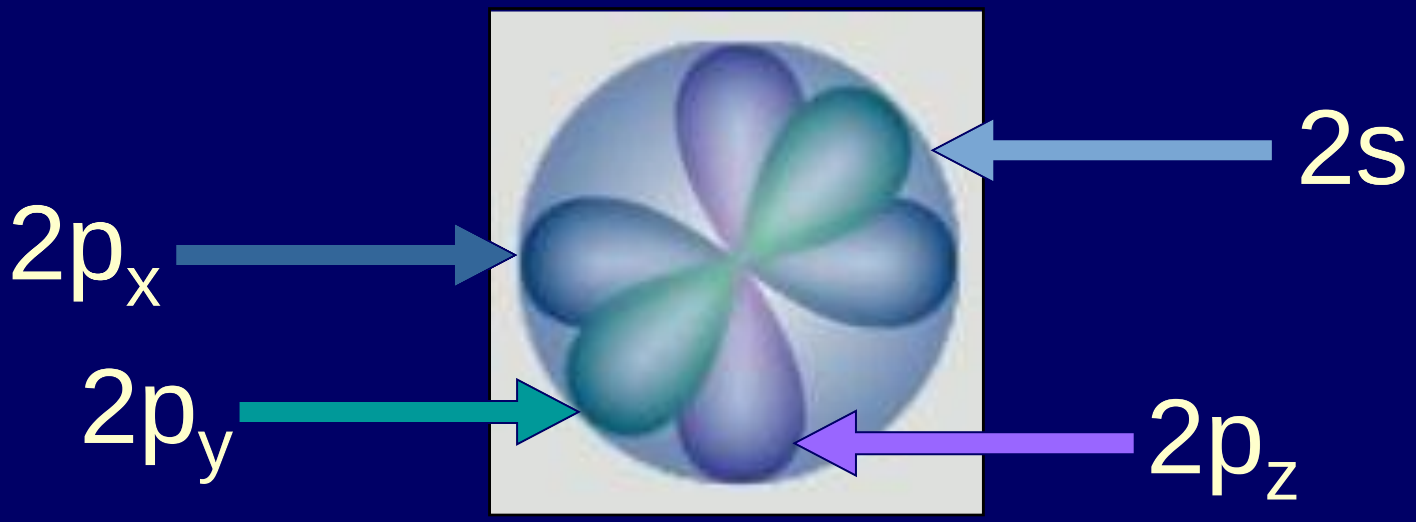
Quantum Numbers





Quantum Numbers

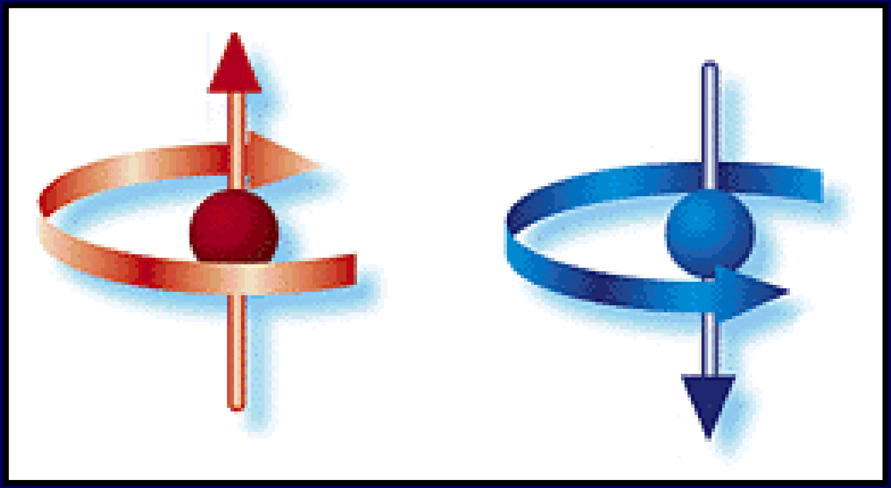
- Orbitals combine to form a spherical shape.



Quantum Numbers

4. Spin Quantum Number (m_s)

- Electron spin ⇒ $m_s = +½$ or $-½$
- An orbital can hold 2 electrons that spin in opposite directions.



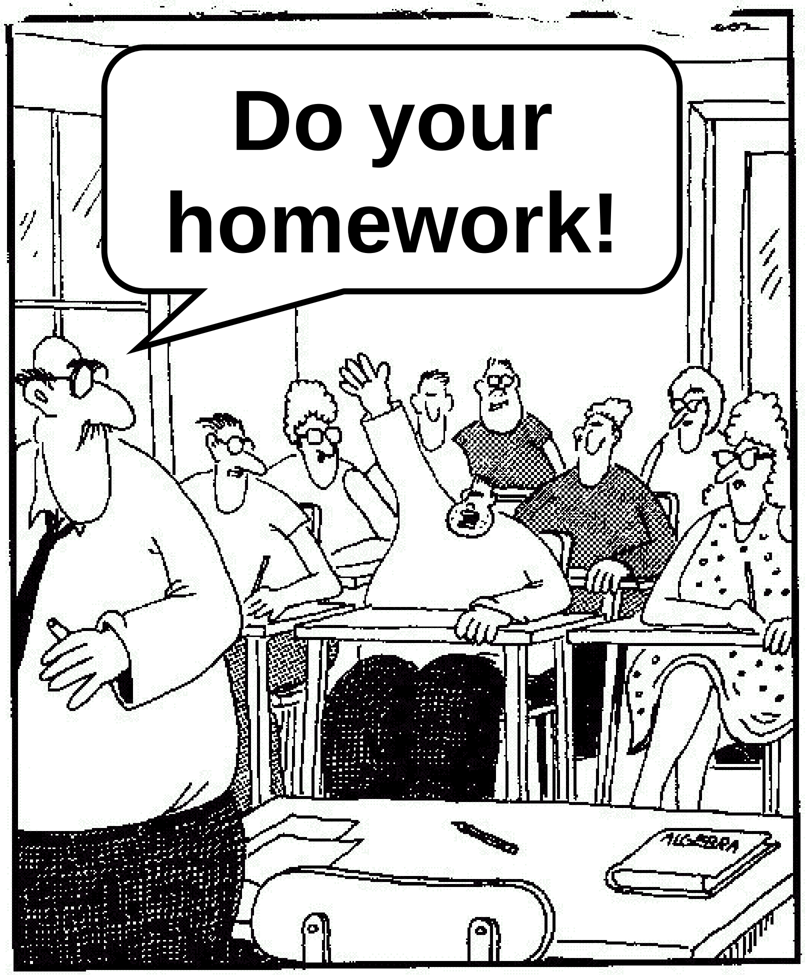
Quantum Numbers

Pauli Exclusion Principle

- No two electrons in an atom can have the same 4 quantum numbers.
- Each e^- has a unique “address”:

1. Principal # → energy level
2. Ang. Mom. # → sublevel (s,p,d,f)
3. Magnetic # → orbital orientation
4. Spin # → electron

Feeling overwhelmed?



Dr. Callaway, may I be excused? My brain is full."