

# The ELECTRON: Wave - Particle Duality

"No familiar conceptions can be woven around the electron. Something unknown is doing we don't know what."

-Sir Arthur Eddington

The Nature of the Physical World (1934)

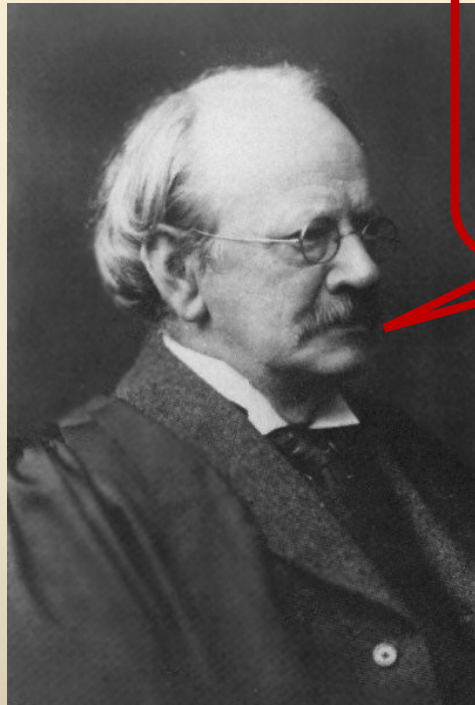
# The Dilemma of the Atom

- Electrons outside the nucleus are attracted to the protons in the nucleus
- Charged particles moving in curved paths lose energy
- What keeps the atom from collapsing?

# Wave-Particle Duality

JJ Thomson won the Nobel prize for describing the electron as a particle.

His son, George Thomson won the Nobel prize for describing the wave-like nature of the electron.



The  
electron is  
a particle!

The  
electron is  
an energy  
wave!



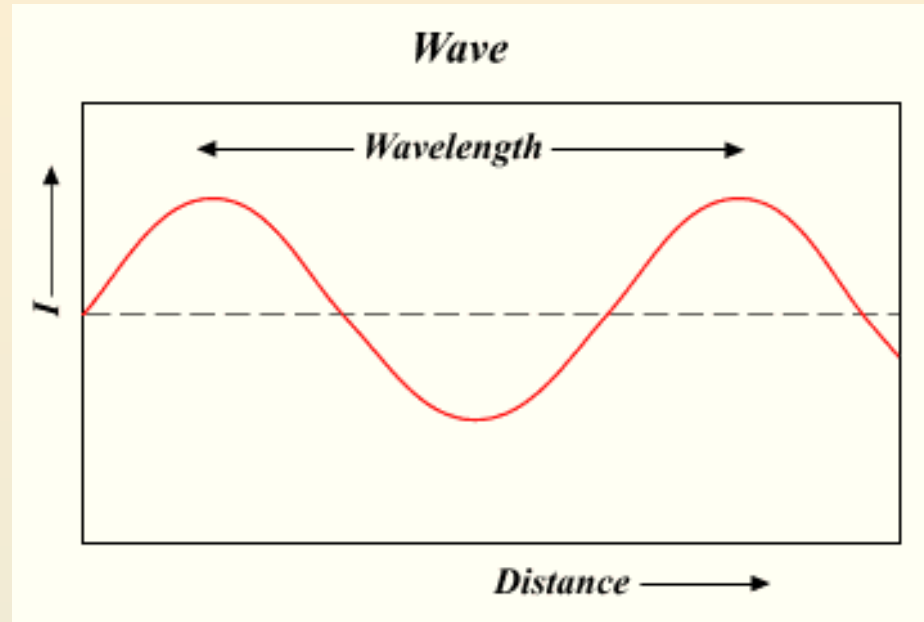
# The Wave-like Electron



The electron propagates through space as an energy wave. To understand the atom, one must understand the behavior of electromagnetic waves.

Louis deBroglie

Electromagnetic radiation propagates through space as a wave moving at the speed of light.



$$c = \nu\lambda$$

$c$  = speed of light, a constant ( $3.00 \times 10^8$  m/s)

$\nu$  = frequency, in units of hertz (hz,  $\text{sec}^{-1}$ )

$\lambda$  = wavelength, in meters

The energy ( $E$ ) of electromagnetic radiation is directly proportional to the frequency ( $\nu$ ) of the radiation.

$$E = h\nu$$

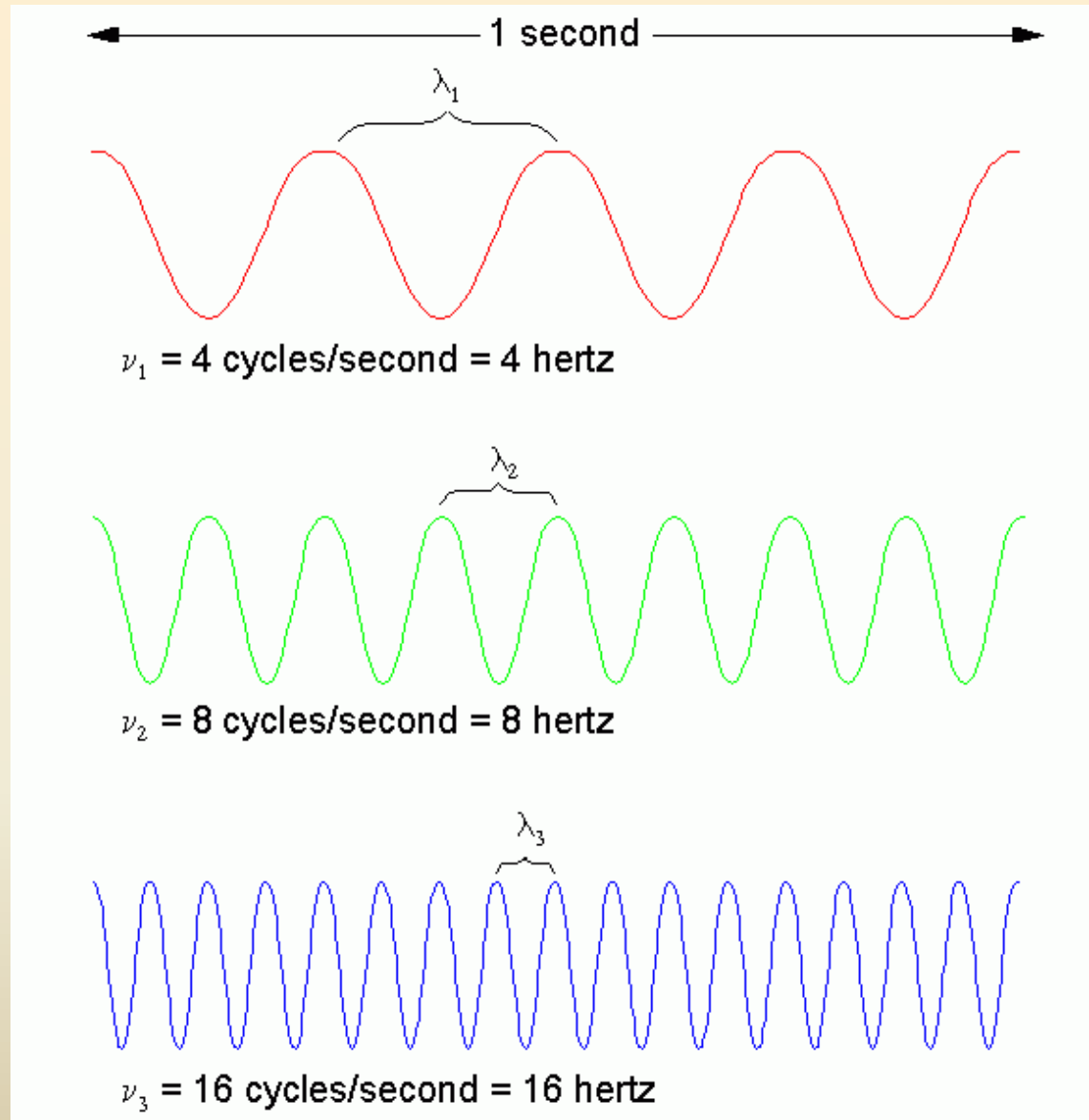
$E$  = Energy, in units of Joules ( $\text{kg} \cdot \text{m}^2/\text{s}^2$ )

$h$  = Planck's constant ( $6.626 \times 10^{-34} \text{ J} \cdot \text{s}$ )

$\nu$  = frequency, in units of hertz ( $\text{hz}$ ,  $\text{sec}^{-1}$ )

Long  
Wavelength  
=  
Low Frequency  
=  
Low ENERGY

Short  
Wavelength  
=  
High  
Frequency  
=  
High ENERGY

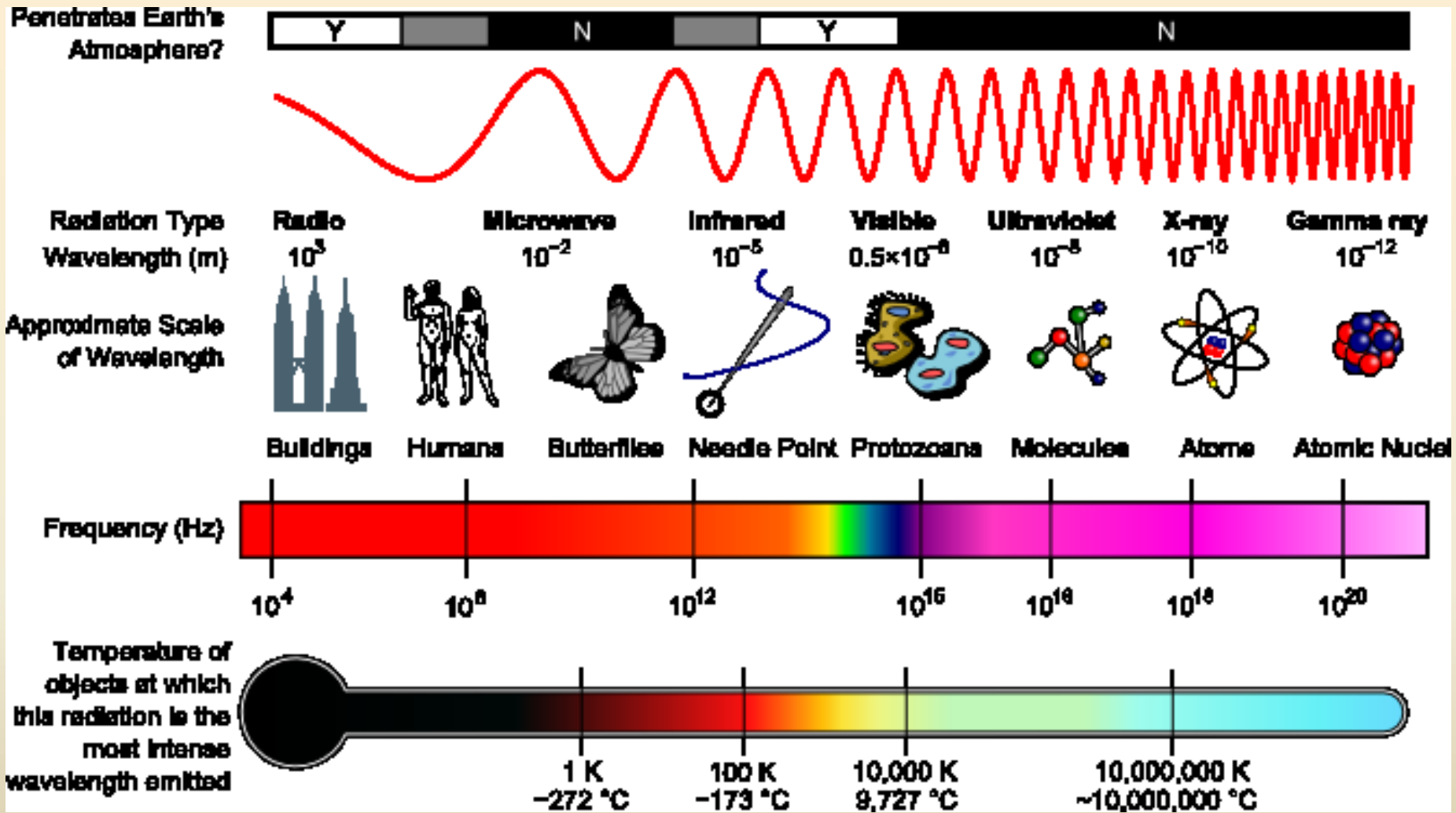


# Answering the Dilemma of the Atom

- Treat electrons as waves
- As the electron moves toward the nucleus, the wavelength shortens
- Shorter wavelength = higher energy
- Higher energy = greater distance from the nucleus

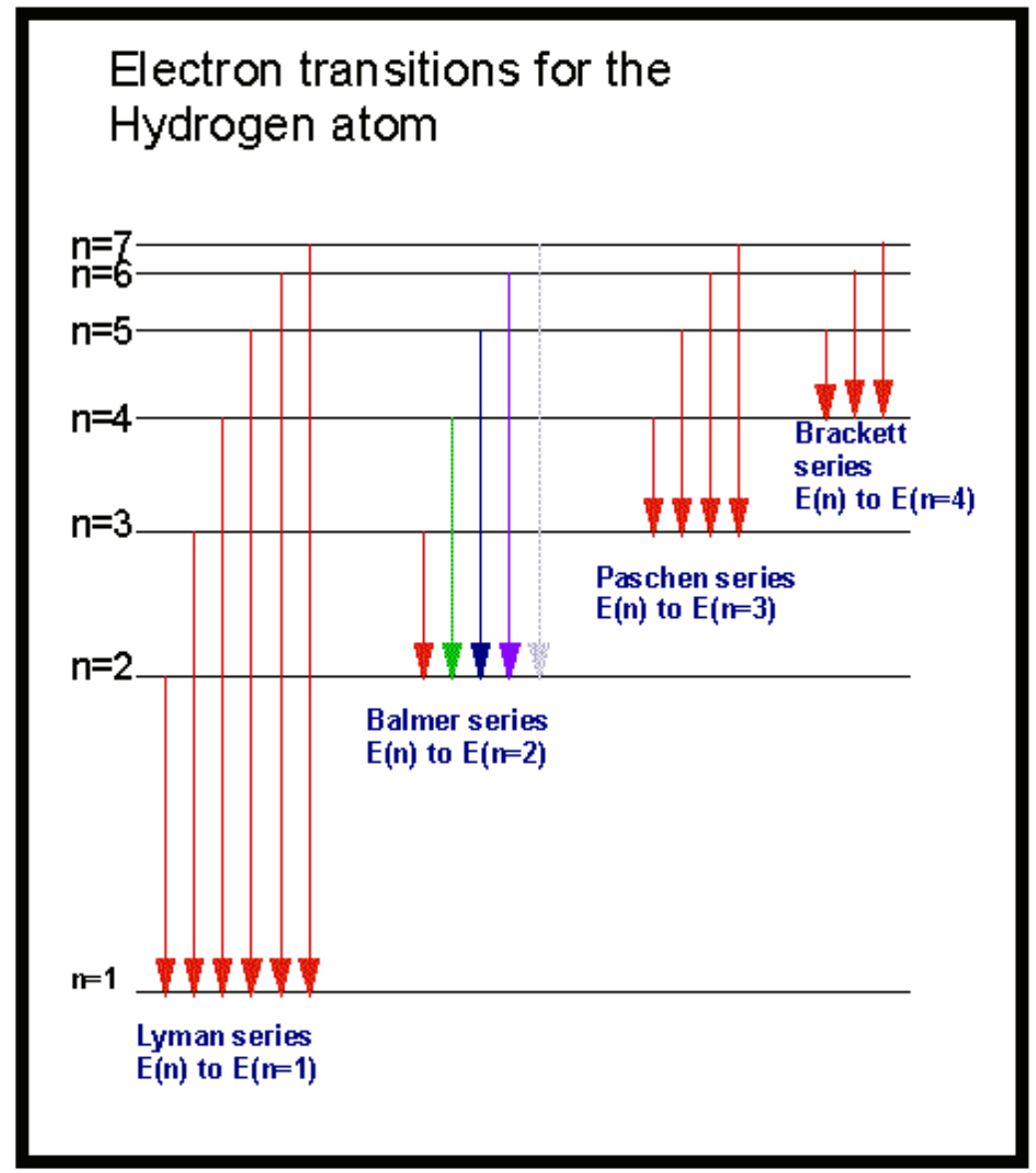


# The Electromagnetic Spectrum

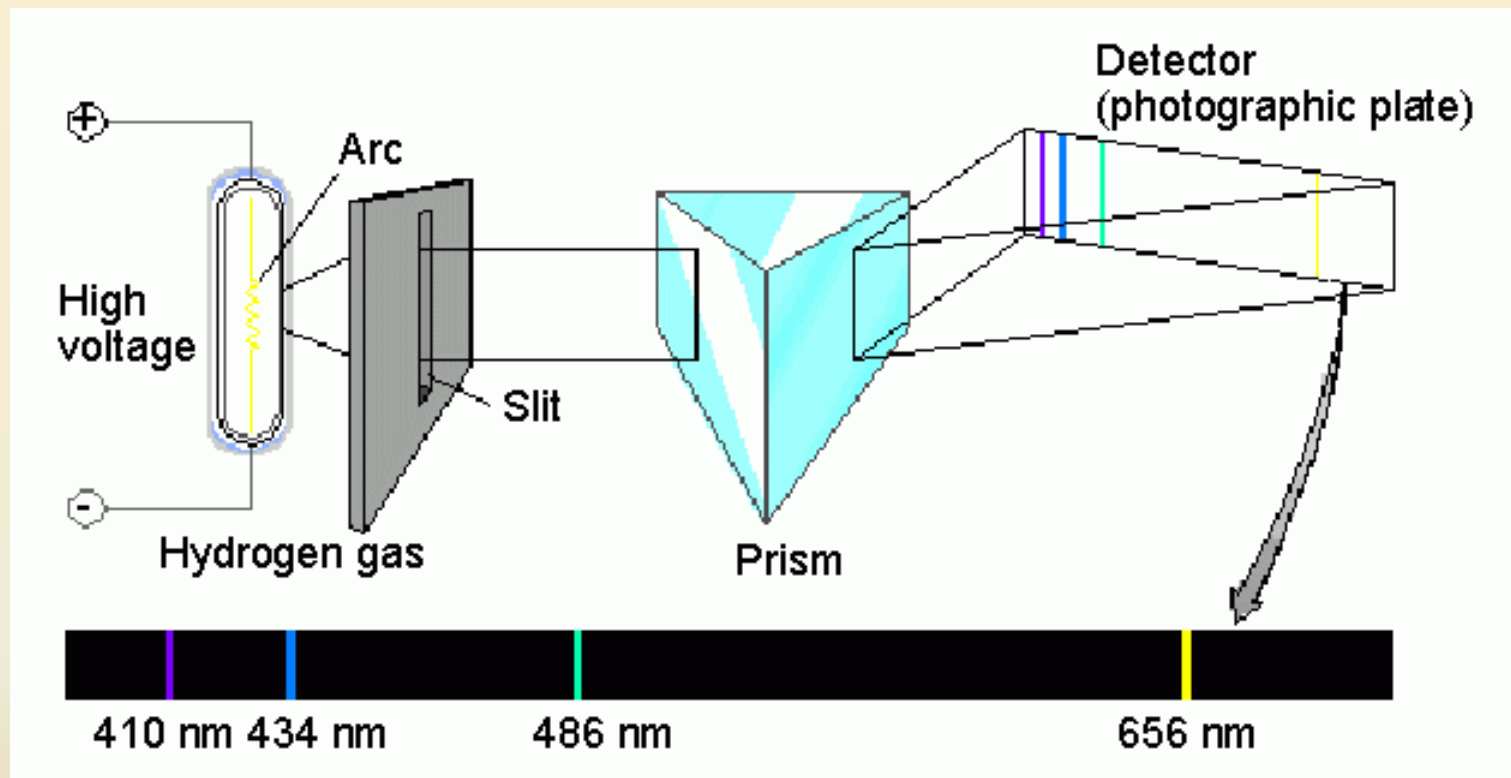


Electron transitions involve jumps of definite amounts of energy.

This produces bands of light with definite wavelengths.



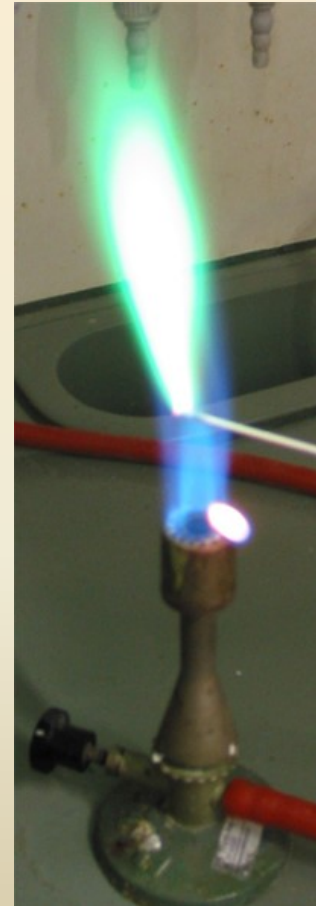
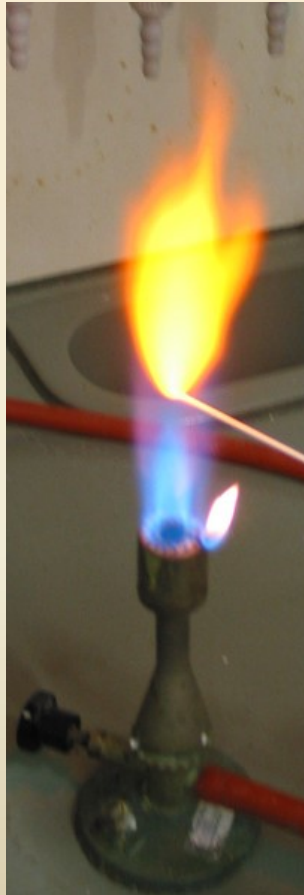
# Spectroscopic analysis of the hydrogen spectrum...



...produces a “bright line” spectrum

# Flame Tests

Many elements give off characteristic light which can be used to help identify them.



strontium

sodium

lithium

potassium

copper