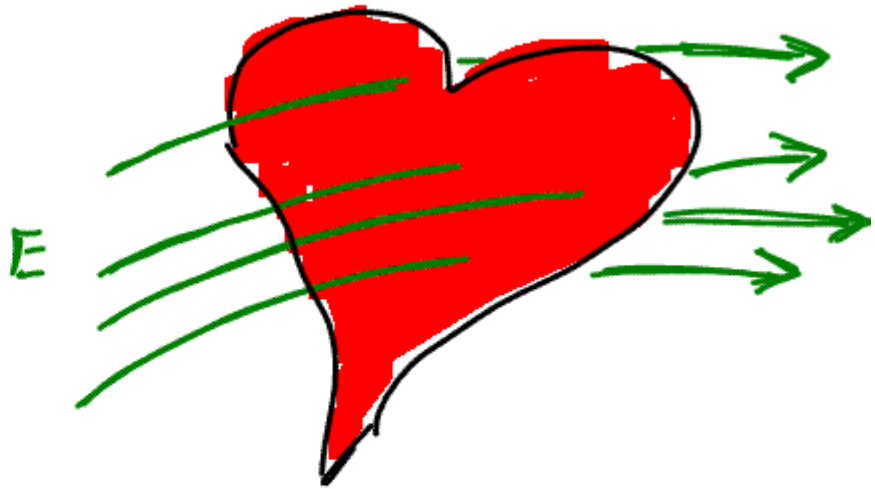
Physics 100 - February 14, 2007

- Feb 9 streaming video
- Feb 21 exam
- Pres. Project groups

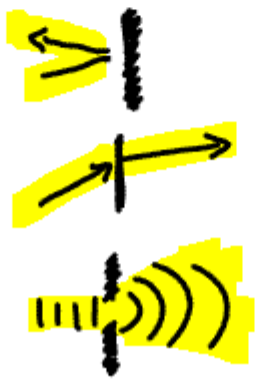


Light is a wave

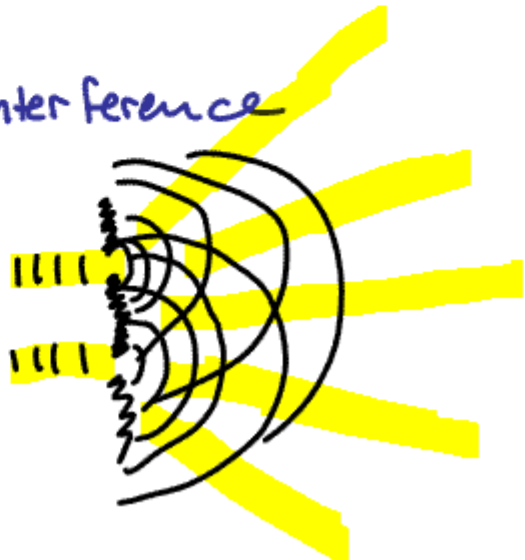
reflection

refraction

Diffraction



Interference



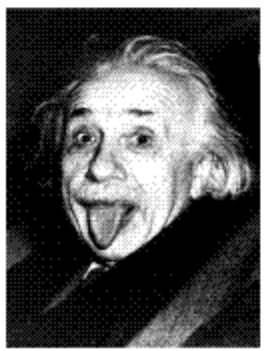
Do Beats (sound beat demo)

Standing Waves

(standing wave on string, Music)

Planck

Blackbody Radiation



Einstein

Photoelectric effect

light comes in little packets with energy $E = h\nu$

light is a particle

As strange as it seems ...

light has both wave and particle properties

wave

$v = \lambda \nu$

particle

$E = h\nu$

The "packet" of energy called the "photon"

↑ Gilbert Lewis, 1926

Prince Louis-Victor Pierre Raymond de Broglie

1892 - 1987 (France)

1929 Nobel Prize in physics

(1924 - doctoral thesis)

Matter Waves

$$\lambda = \frac{h}{p}$$

recall $p \sim mv$

λ: wavelength of particle of matter

h: plank's constant

p: momentum

Yikes! Quantum Mechanics is born

$h = 6.6 \times 10^{-34}$ Joule-sec

$h = (2\pi)(6.6 \times 10^{-22})$ MeV-sec

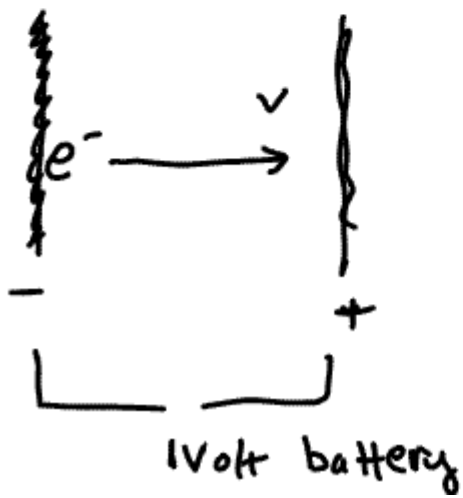
$E = h\nu$ Joules-S

Joules $\quad \frac{1}{S}$

Joule - Energy unit — Work unit MKS

Work = (force)(dist) = (Newton)(M)

eV ≡ electron-Volt unit of energy Convenient for particles



1 eV = 1.6×10^{-19} Joules

Energy gained by electron as it Moves from one terminal to the other in a 1 volt battery

Units of energy commonly used in physics of atoms and particles

eV	
KeV	Thousand of eV
MeV	Millions of eV
GeV	Billion of eV
TeV	Thousands of Billion eV

Energy + Mass related by $E = mc^2$

eV

Mass of particle ~ $\frac{eV}{c^2}$

$0.511\ MeV/c^2$ = electron mass

Common to ignore the c^2 and refer to masses in terms of eV or MeV

If $\lambda = h/p$ for matter, why do we NOT have to worry about wave effects of matter in everyday life?

$\lambda = \frac{h}{p}$

baseball at 92 mph

Mass 142 g

41 m/s

P of baseball = mv

$p = 5.7 \text{ kg m/s}$

$$\lambda_{\substack{92 \text{ mph} \\ \text{baseball}}} = \frac{6.6 \times 10^{-34} \text{ J·s}}{5.7 \text{ kg m/s}}$$

$\lambda = 1. \times 10^{-34} \text{ m}$

Incredibly small wavelength — not noticeable to us.

1 eV electron

energy of 1.6×10^{-19} J

$= \frac{1}{2} m v^2 \rightarrow v = 596$ m/s

$p = (9 \times 10^{-31}\ kg)(596) = 5 \times 10^{-28}\ kg\ m/s$

$$\lambda_{e^-} = \frac{6.6 \times 10^{-34}}{5 \times 10^{-28}} = 1.3 \times 10^{-6}\ m$$

$\sim 1\ \mu m$

Can use electron waves to image very small objects because electron wavelength is smaller than wavelength of visible light

$\lambda = h/p$

higher Energy or p → smaller λ of electron

Not so incredibly small

careful experiments can see wave effects like diffraction and interference of electrons

Niels Bohr

(1885 - 1962) (Denmark)

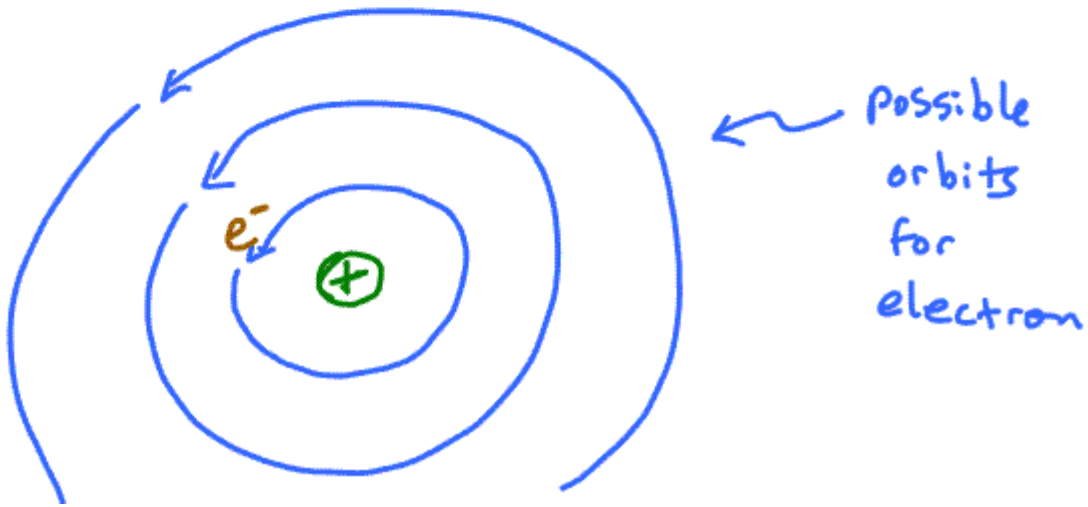
1922 Nobel Prize in Physics

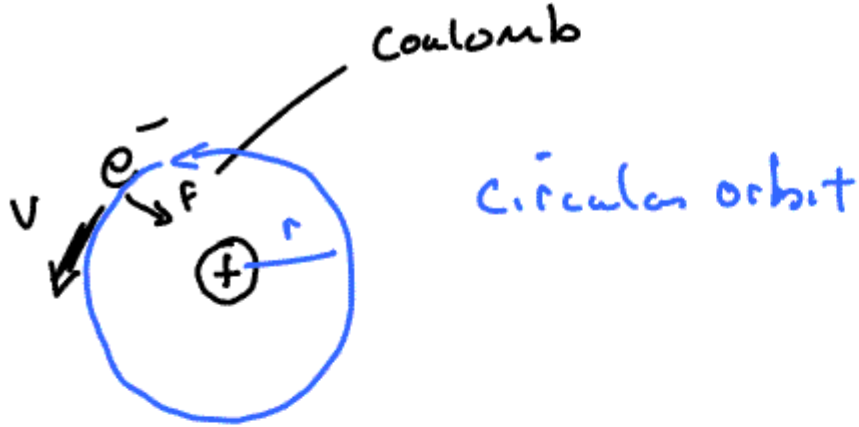
Atomic (planetary) model with fixed orbits

nicely motivated by de Broglie's matter waves in 1924

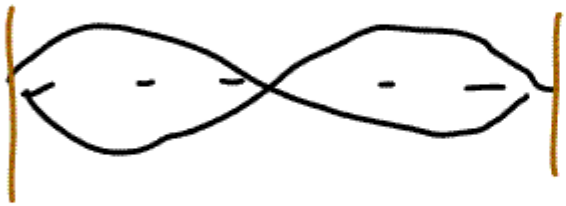
Bohr model of the atom

- positive Nucleus
- electrons orbit in circles
- only particular "discrete" orbits allowed
  - ↑ known as quantization
- electric (Coulomb) Force holds electron on Circle as it orbits ... attracts electron toward Nucleus





circular orbit



Recall "standing waves" on a string demo. Waves travel down string and reflect. Waves travel down string and interfere w/ reflected waves travelling back

only get "resonance" or stable system when wave and reflected wave interfere constructively

Imagine attaching one end of string to the other in a circle

If electron is a wave in Bohr model circular orbit, Electron can only exist in orbits where the electron wave interferes constructively with itself as you go around the circle.

⇒ only particular circumferences and circle sizes (radii) will work

Leads to quantization

$$F_{center} = \frac{mv^2}{R}$$

condition for Circular Motion

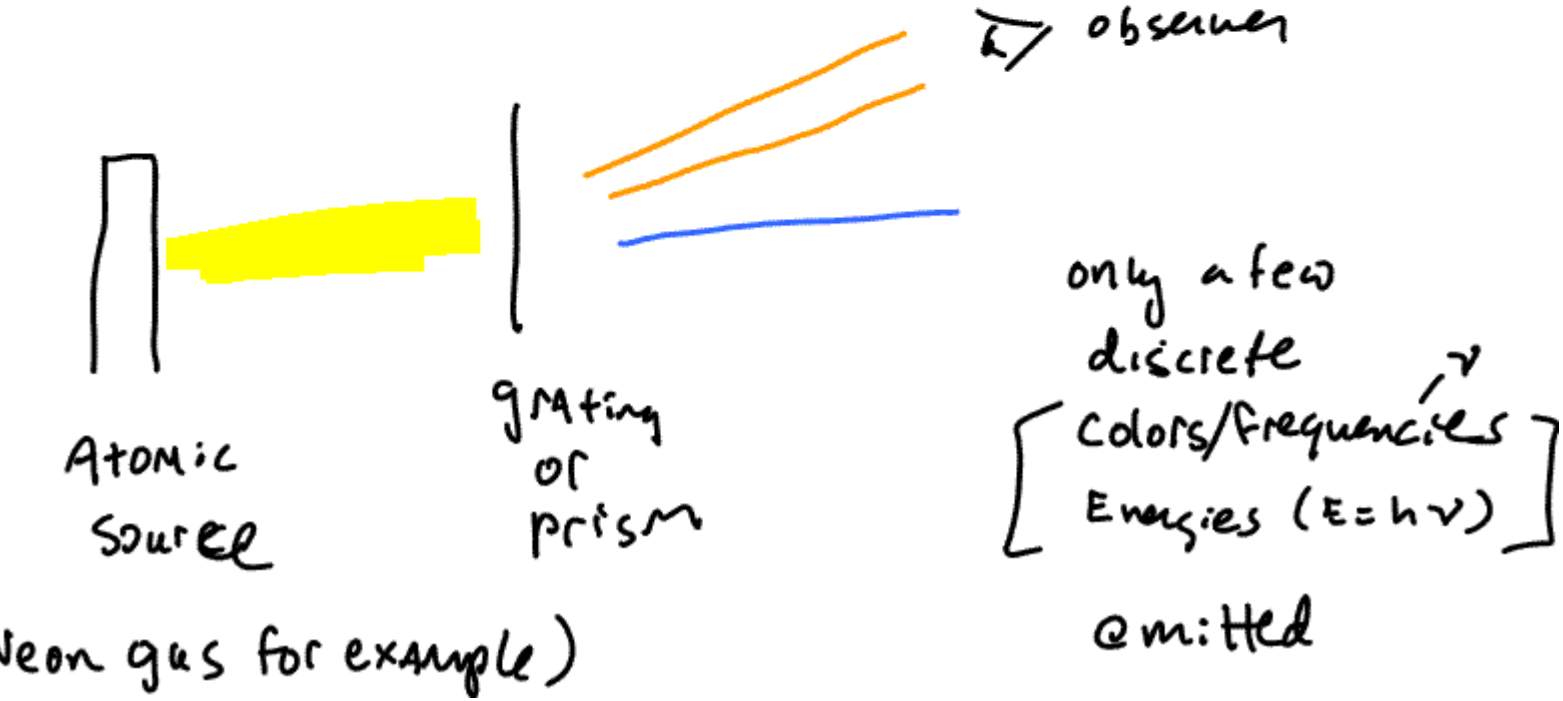
quantized orbits lead to quantized electron energies

light absorbed and emitted as electron jumps from one orbit w/ fixed energy to another.

→ leads to discrete Atomic spectra

given R → fixed energy


observer
See continuous rainbow
white light source
grating or prism


observer
Atomic source
grating or prism
only a few discrete colors/frequencies ν
Energies (E = hν)
emitted
(Neon gas for example)