Physics 100 - October 3, 2007

Exam 1 - Oct 10 during class time slot

- Bring calculator
  (capable of Scientific Notation)
- Index card
- Formula Sheet
- Previous exams on web
- Q + A session

Material coverage thru

- Electromagnetic Waves / waves
- Readings thru Sept 26 on Syllabus
- Lectures Thru Sept 26 (minus Planck at end)
- Prob Sets 1 Thru 4
- Recitations 1 Thru 3

Last Time

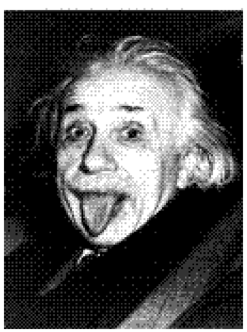
Do ripple tank Applet

Maxwell's equations
interference
diffraction
Refraction
dispersion
⋮

light is a wave!

Planck

Blackbody Radiation



Einstein

Photoelectric effect

light comes in little packets with energy

$E = h\nu$

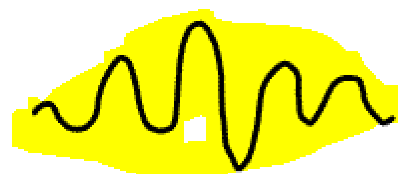
light is a particle!

Wave-Particle Duality

As strange as it seems...

light has both wave and particle properties

wave $v = \lambda \nu$



particle $E = h\nu$

The "packet" w/ energy called the "photon"

↑ Gilbert Lewis, 1926

 $\rightarrow v$

Light is a wave $\quad v = \lambda\nu$

And

a particle $\quad E = h\nu$

Einstein
Planck

Particles (like electrons)

• $\rightarrow v$ $\quad$ are

$p = mv$ $\quad$ particles And waves

$\lambda = \frac{h}{p}$ $\quad$ de Broglie

$h = 6.67 \times 10^{-34}\ J \cdot s \Rightarrow$ very small

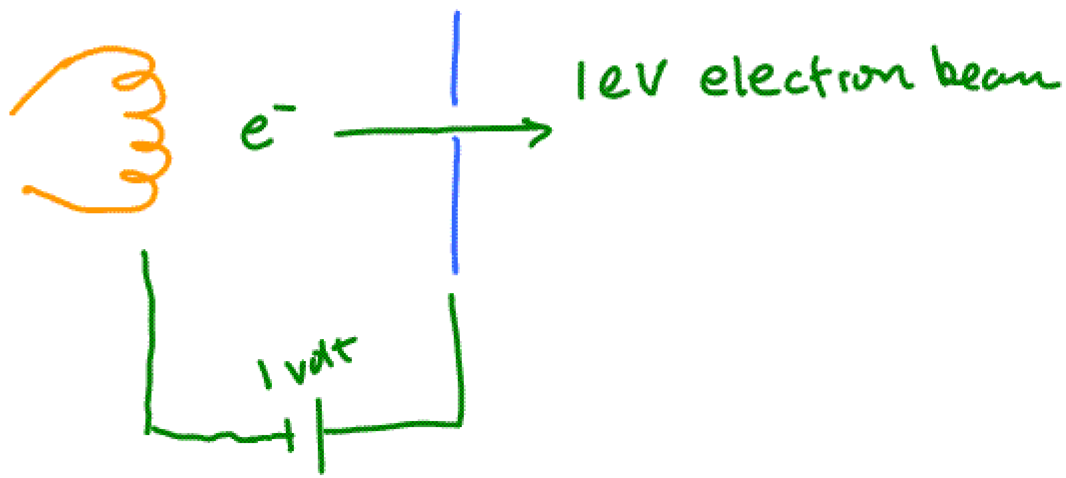
So p must be very small for λ

to be large

impt for small particles moving slow

particle energy often meas. in eV

$1 \text{ eV} = 1.6 \times 10^{-19}$ Joules



keV
MeV
GeV
TeV
⋮

mass — eV/c^2

$E = mc^2$

$E/c^2 = m$

mass of electron $= 9.11 \times 10^{-31}$ kg $= 0.511 \text{ MeV}/c^2$

Sometimes people forget the "c^2" here ↗

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

λ of baseball at 92 mph

↑ mass ~ 142 g

↑ 41 m/s

P of Baseball $= mv = (.142\,\text{kg})(41\,\text{m/s})$

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

$$\lambda = \frac{6.6\times10^{-34}\ \text{J}\cdot\text{s}}{5.7\ \text{kg m/s}} = 1\times10^{-34}\ \text{m}$$

1 eV electron

↳ Energy $= 1.6 \times 10^{-19}$ Joules $= \frac{1}{2} m v^2$

$$v = 596 \ m/s$$

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

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

$$\sim 1 \ \mu m$$

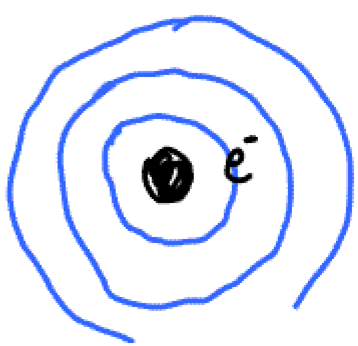
Niels Bohr

(1885 - 1962)   (Denmark)

1922 Nobel Prize in Physics

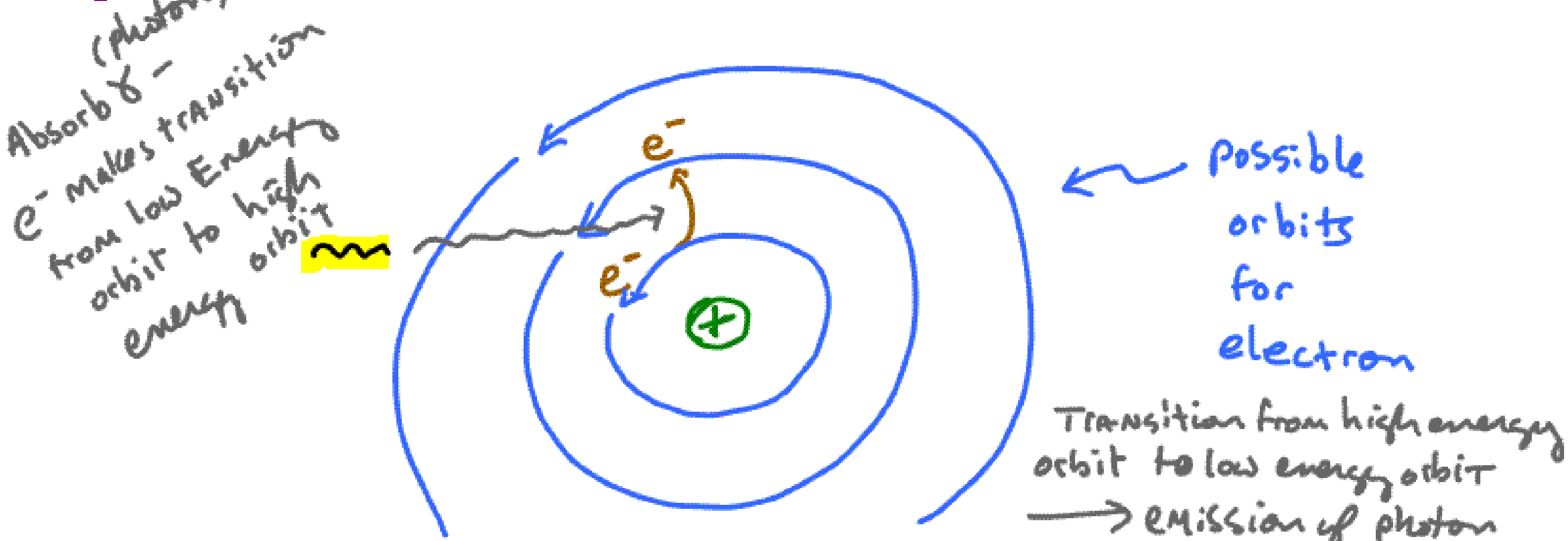
Atomic (planetary) model with fixed orbits

nicely motivated by de Broglie's matter waves in 1924

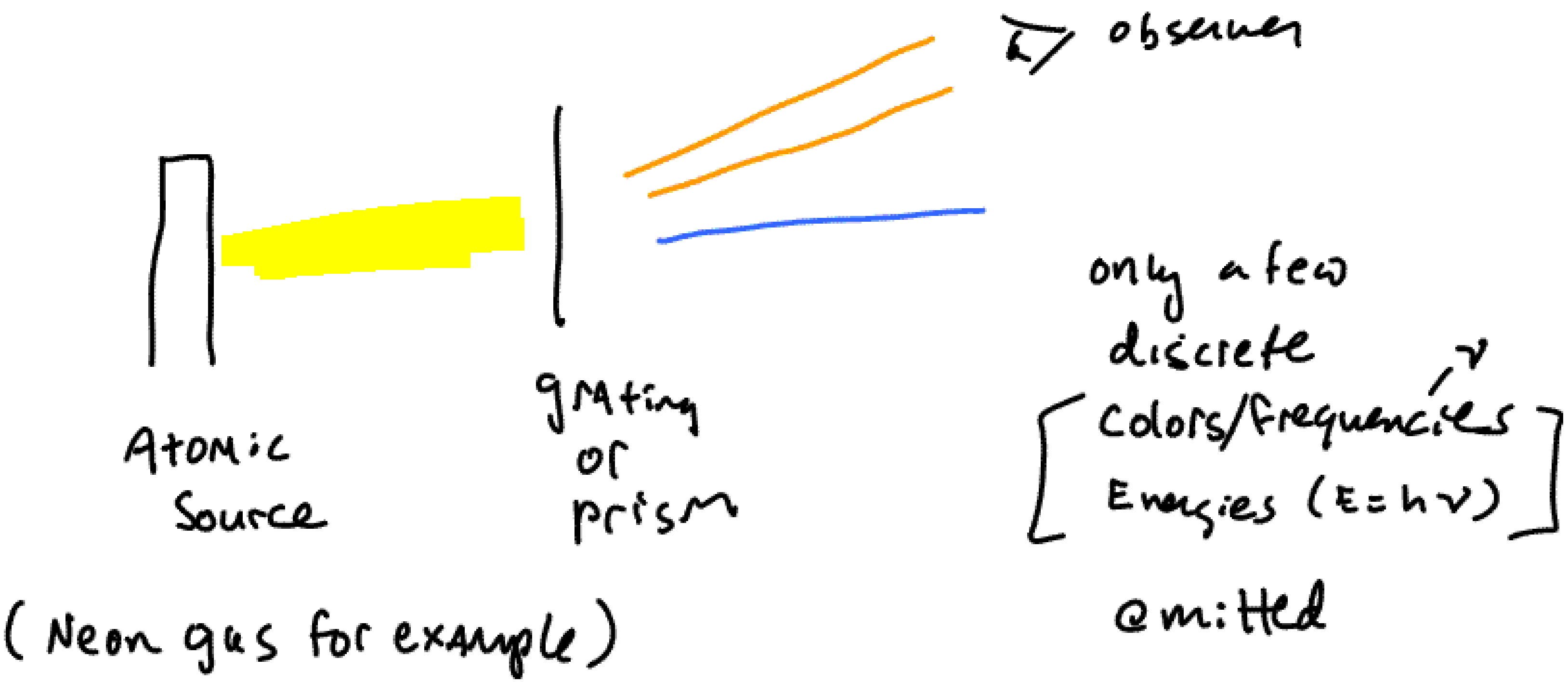


Bohr Model of Atom (1912)

- Positive nucleus (nuclear)
- e^- orbit nucleus in circles
- nucleus does not move
- e^- only occupies certain discrete orbits
  - ↑ known as quantization
- Coulomb force holds e^- in orbit




observer
See continuous rainbow
white light source
grating or prism


observer
Atomic Source
grating or prism
only a few discrete
colors/frequencies
Energies ($E = h\nu$)
emitted
(Neon gas for example)

* Do Bohr Model Applet (see links page on website)

Discrete Atom Emission + Absorption lines come from e^- transitions between discrete Energy levels

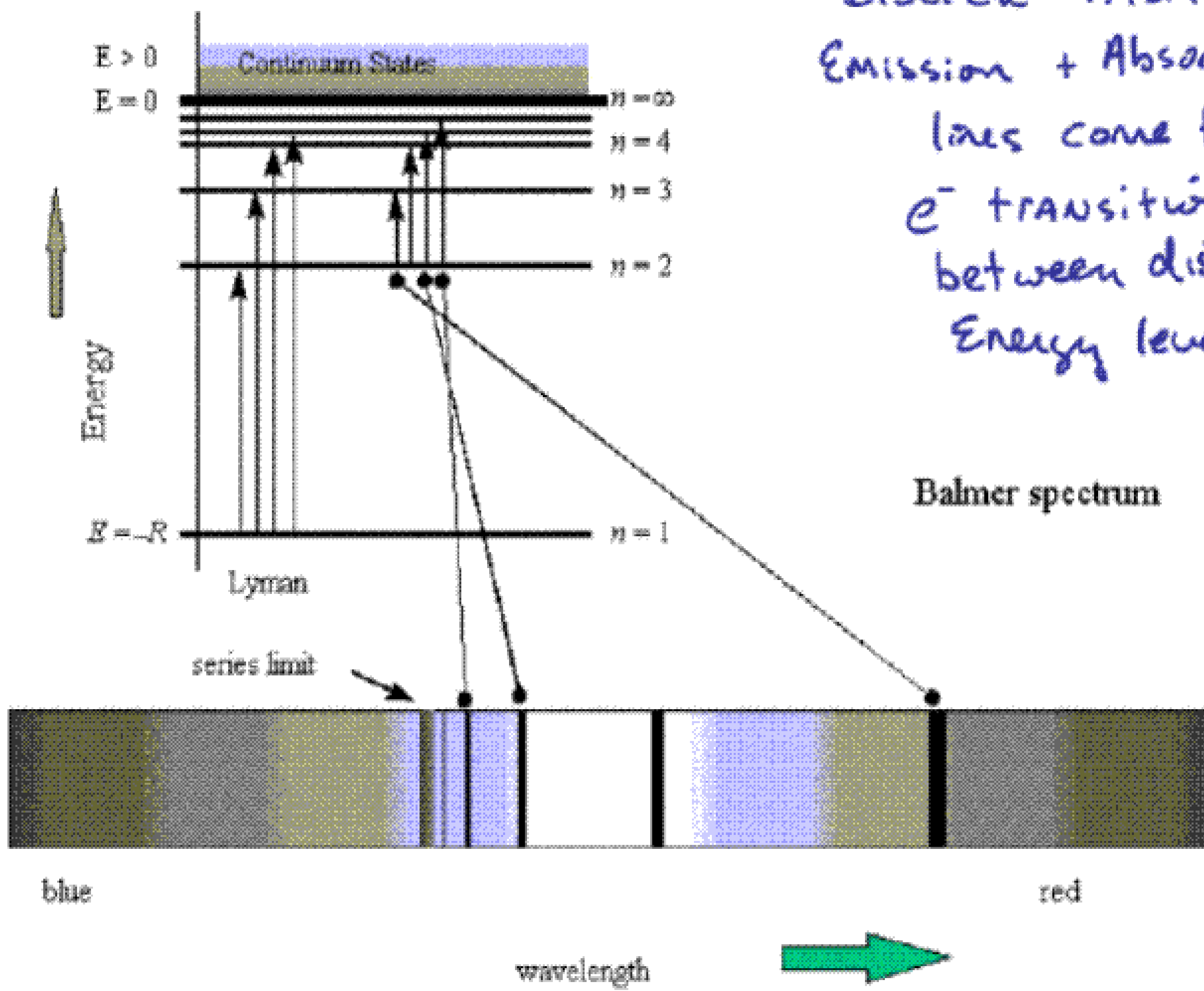


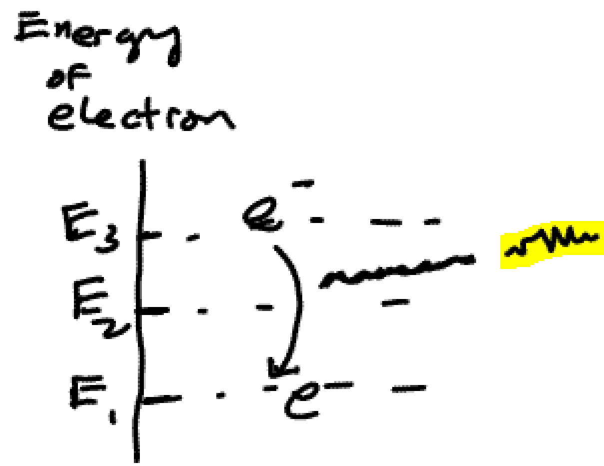
Figure from http://www.uclan.ac.uk/facs/science/physastr/x99/PAM98/UCert/Ch06/6_6ato~1.htm

- Bohr model of atom worked well in describing the discrete spectra observed coming from atoms.
- In this model photons are only absorbed/emitted as electron makes transitions between specific allowed energy states.

So photons have fixed energies

$E = h\nu$

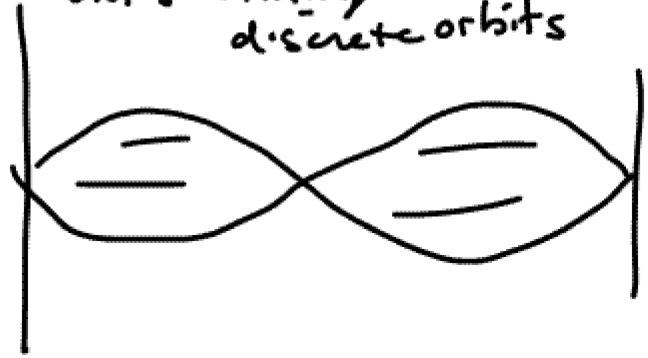
↑ means light is emitted with specific colors



- Bohr model orbits are stable ... not easily understandable with classical physics
  NOT motivated by Bohr ... just put in ad hoc to get discrete spectra

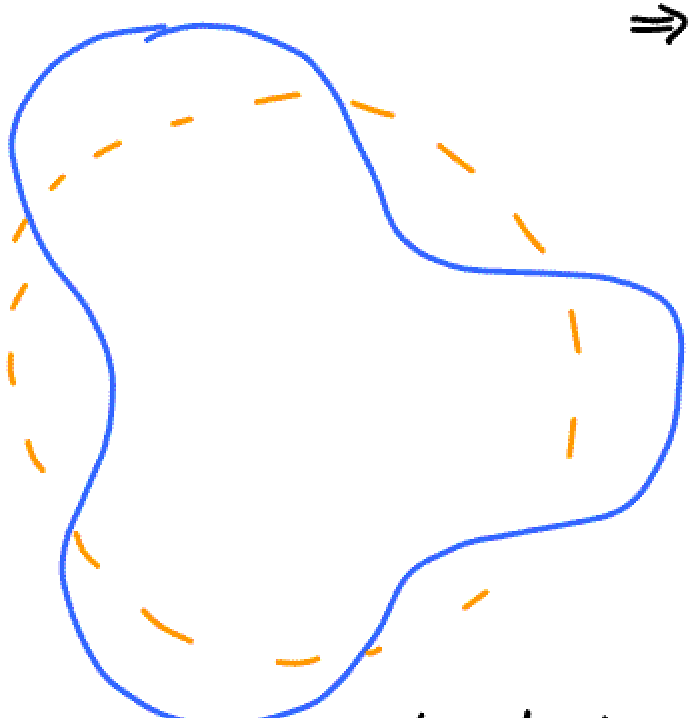
Next step: development of true wave equation/solution for matter

de Broglie Matter wave idea
Motivates Bohr's strange discrete orbits



Recall demo of "standing waves" on a string
waves travelling →
interfere w/ reflected
waves travelling ←
to create resonance
⇒ only for specific wavelengths or frequencies

Only orbits where wavelength of electron is correct length to form standing wave around the circle of orbit are stable



→ leads to discrete stable orbits

Werner Karl Heisenberg

(1901 - 1976)

Nobel Prize in physics - 1932

for "the creation of quantum mechanics"

(Max Born, Pascual Jordan - co-workers)

Erwin Rudolf Josef Alexander Schrödinger

(1887 - 1961) Austria

1933 Nobel Prize in physics

1926 - Paper on wave Mechanics of Matter
Annalen der Physik

"for discovery of new and productive forms of atomic theory"

$$-\frac{\hbar^2}{2m}\frac{d^2\psi(x)}{dx^2} + V\psi(x) = E\psi(x)$$

Schrödinger's Equation

Just so you've seen it