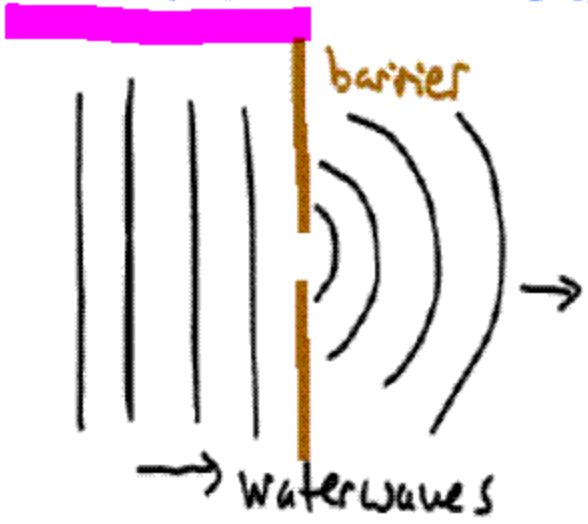
Physics 100 - February 11, 2009

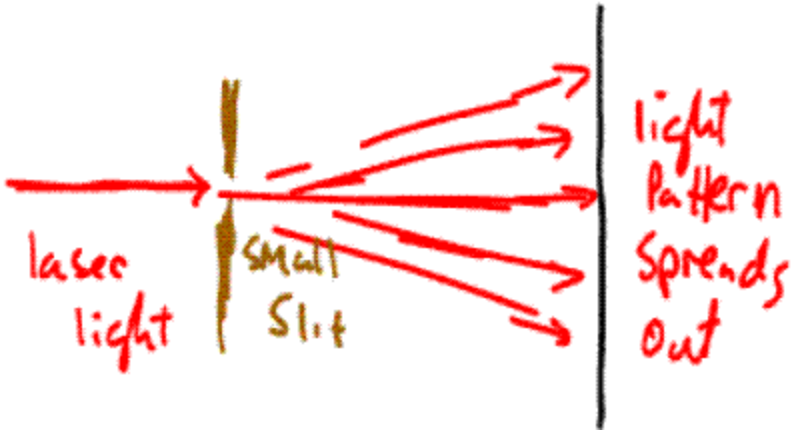
- No lecture Monday — catch it online

Last Time

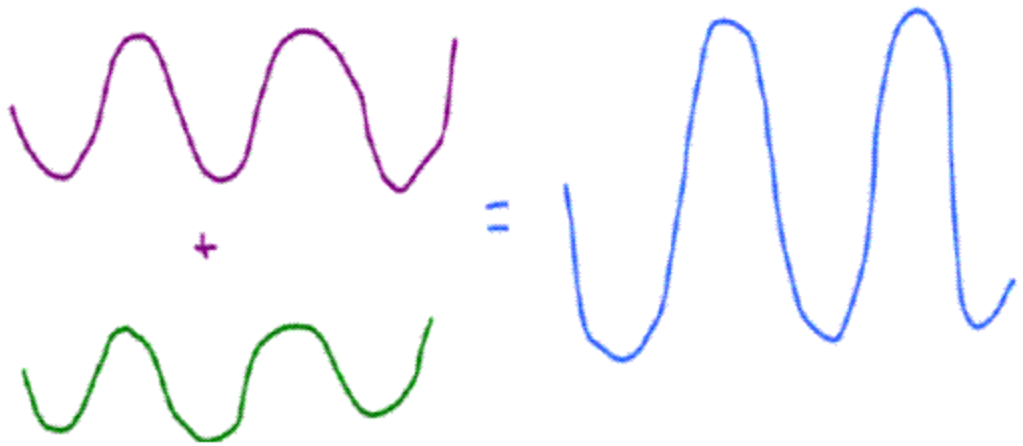
light is a wave

Diffraction – waves spread out passing thru small hole

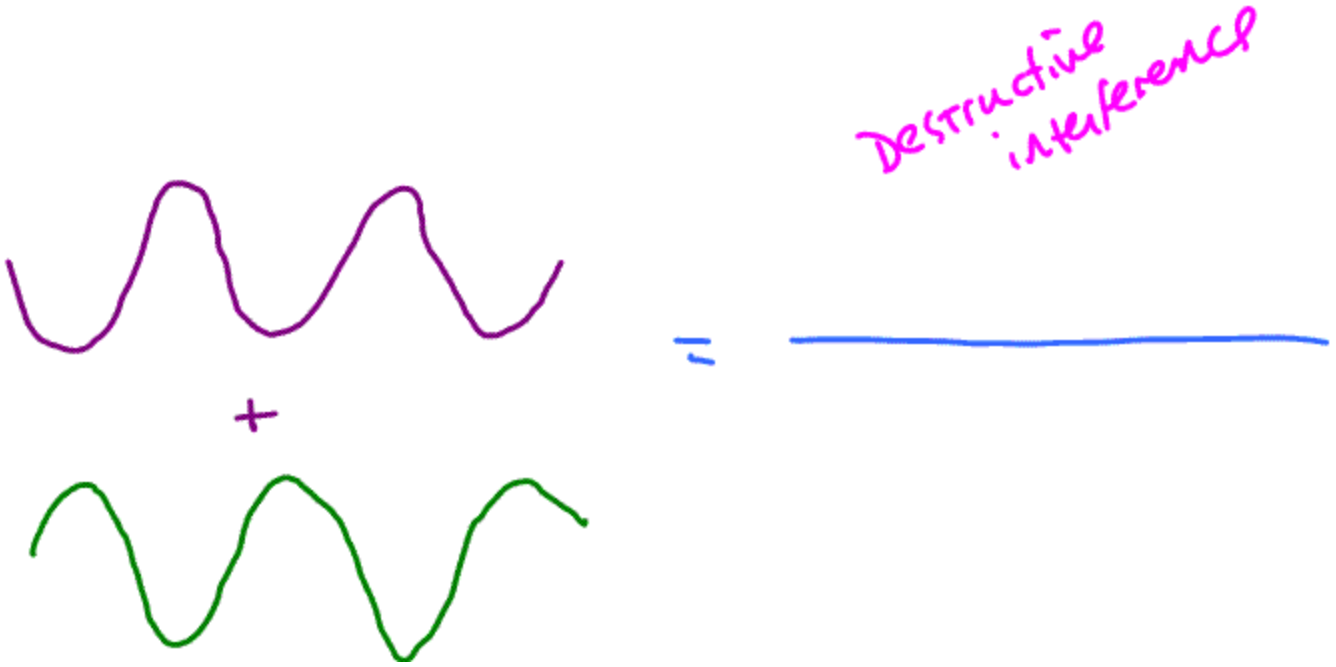




Interference - Wave Amplitudes Add together

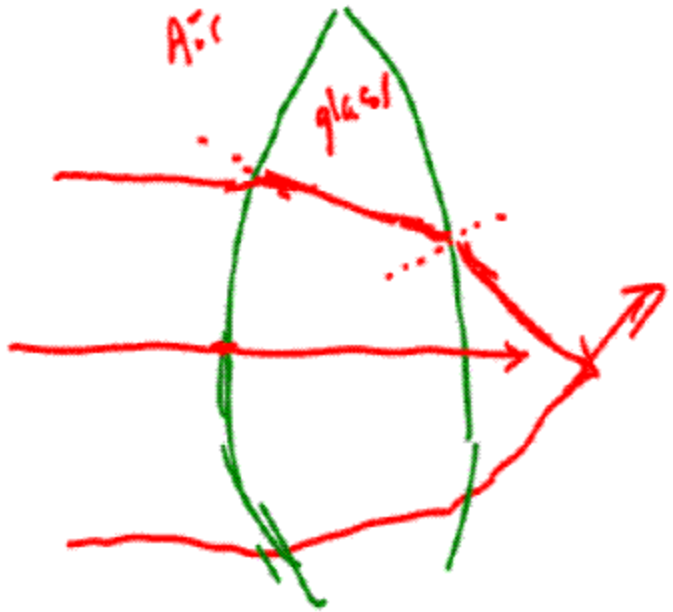


constructive Interference



Destructive interference

Refraction - waves bend at interface between media



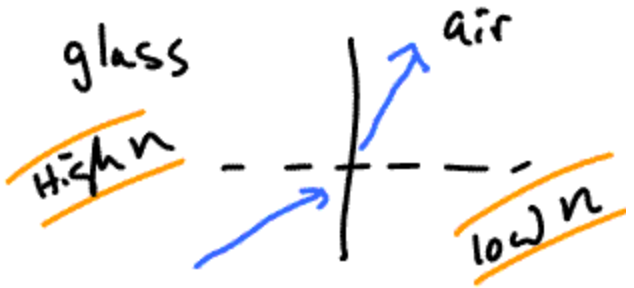
Wave characteristics of light ...

key to optics

vacuum ~ air ~ 1

index of refraction $n = \frac{c}{v} \geq 1$

v ≡ speed of light in the material



So, we Know light is a wave and it

is well understood thru Maxwell's equations.

Try to use this deep understANDing

of waves to probe the nature of

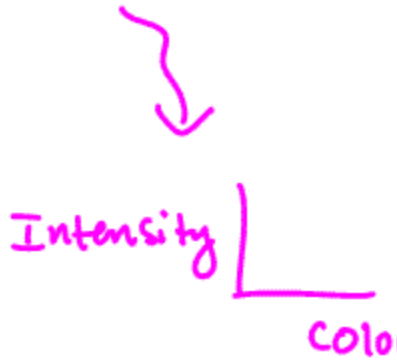
matter

Can we understAND the "Spectrum"

of light emitted

by a "glowing"

object?



NO! ... NOT with the wave theory of light. IT Fails

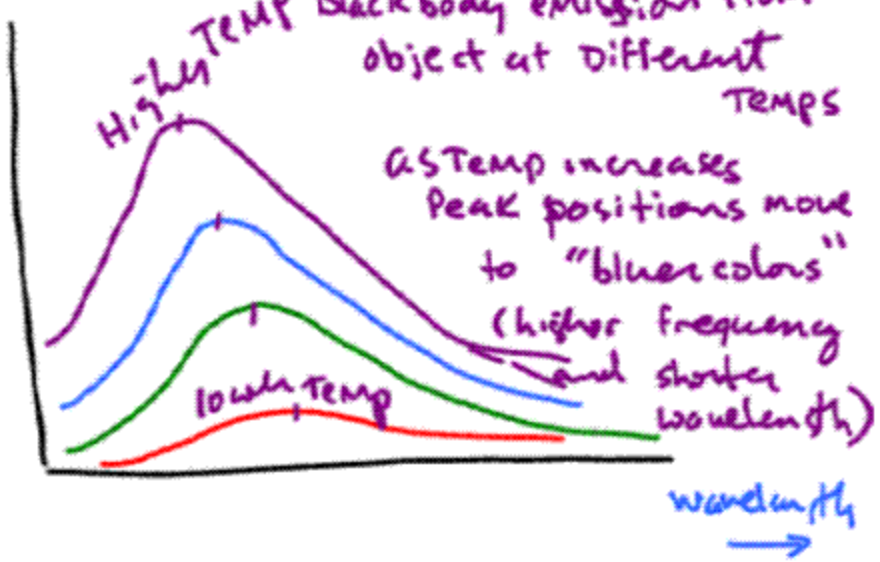
Max Planck

(1858 - 1947)

German national

http://www-history.mcs.st-andrews.ac.uk/Mathematicians/Planck.html

Awarded 1918 Nobel Prize in physics for analysis of blackbody radiation which contributed to rise of quantum Mechanics



Planck succeeded in describing Black body radiation

light exists in packets of energy

Discrete

Particle

"photons"

Planck's CONSTANT

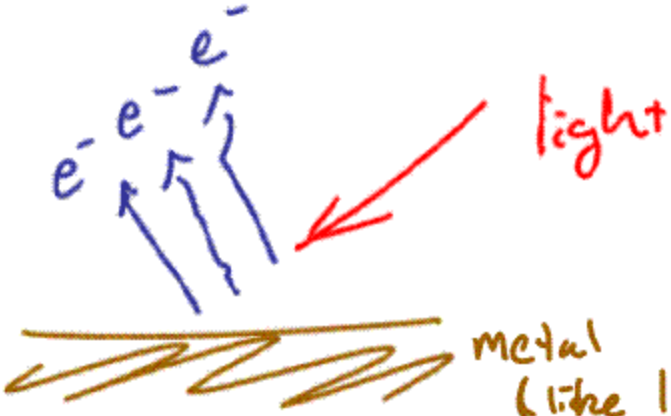
$$E = h\nu$$

Energy

Frequency

Planck's Theory worked perfectly ... but physicists thought it was a fortuitous Accident ... after all, light is a wave.

Another phenomenon that was NOT understood



Photoelectric effect

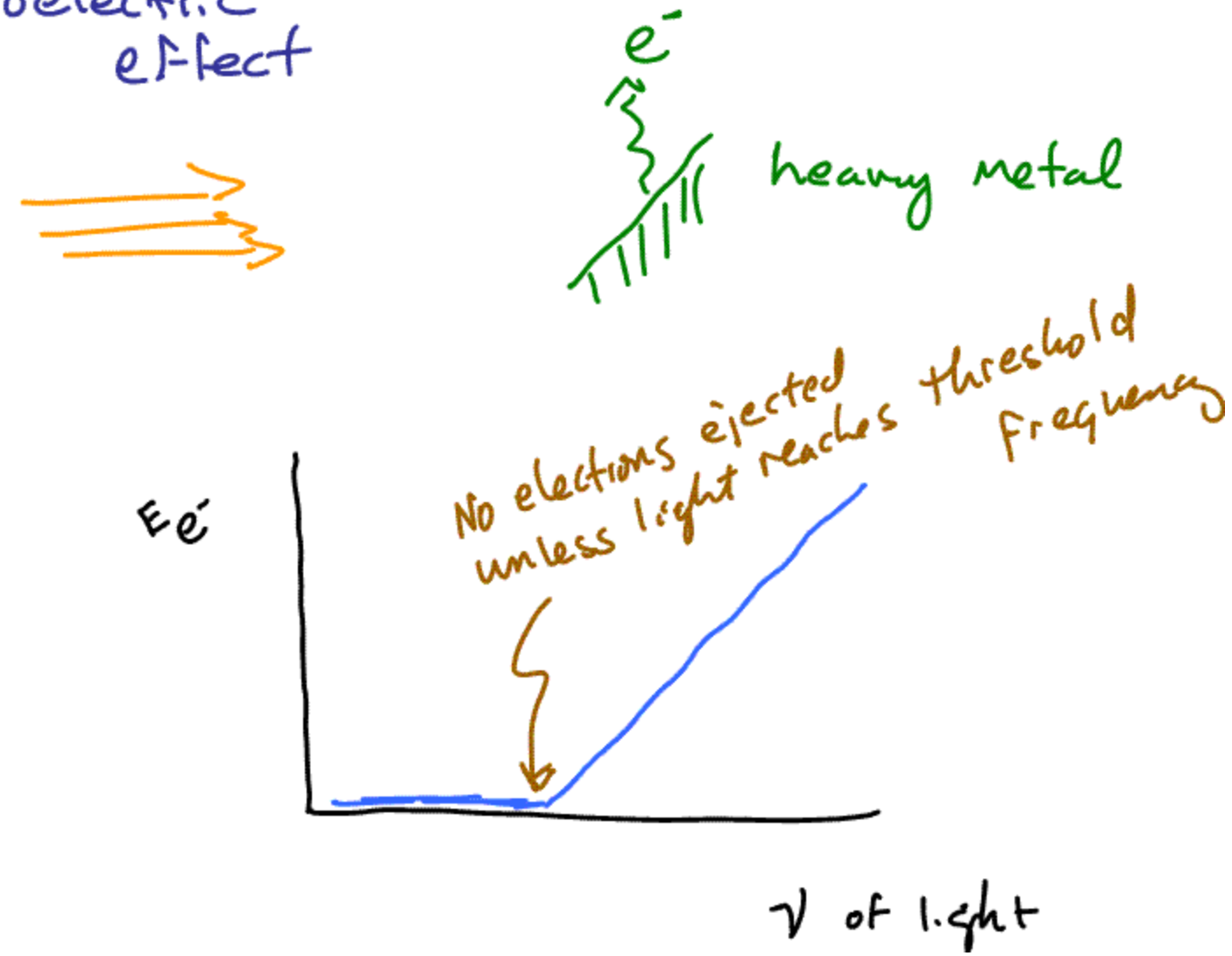
Study electric current depends on Intensity + color of light

Einstein in 1905

$E = h\nu$

- Einstein able to explain photoelectric effect
  Assuming light to come in little packets
  with energy $E = h\nu$
- Light as wave theory could not account for data
- Suddenly world has to face fact that light is both a wave and a particle
  ... Sounds crazy ... but that's what nature tells us.

Photoelectric effect



Prince Louis-Victor Pierre Raymond de Broglie

1892 - 1987 (France)

1929 Nobel Prize in physics

If light can have both wave and particle properties ... why can't matter have both wave and particle properties

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

λ: wavelength of Particle of matter

p: momentum $\equiv mv$

Birth of Quantum Mechanics

$h = 6.6 \times 10^{-34}$ Joule-Sec ← metric

$h = 2\pi \times 6.6 \times 10^{-22}$ MeV-Sec

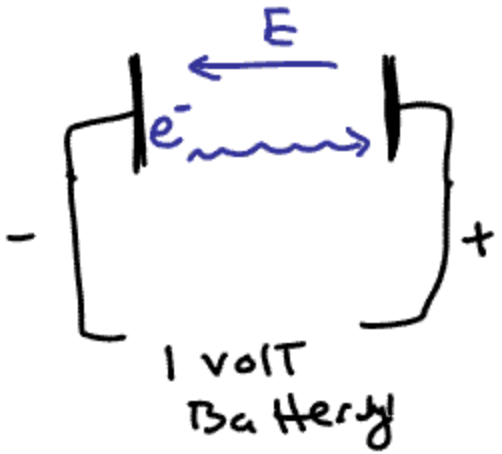
$\hbar = \frac{h}{2\pi}$

$E = h\nu$ (ν: $\frac{1}{s}$)

↑ Joules, MeV

meter-Kilogram-second metric system of units

Joule MKS unit of work



electron gains 1 electron-Volt of Energy

1 eV of energy

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

eV
keV Thousands of eV
MeV Million of eV
GeV Billions of eV
TeV Thousands of Billions of eV

} Atom, nucleus, subatomic particles

Joules ≡ good unit of energy for everyday life (tossing a baseball)

eV ≡ convenient unit of energy for atomic and nuclear processes