Physics 102 - September 28, 2009

No lecture at 2 pm
on Wed., Sept 30, 2009

PDF Slides + mp3 Audio
File will be posted on
class website ~ Hopefully by 2
on Wed.

I will assume you have
looked at/listened to this

Maxwell's Equations

1873

James Clerk Maxwell

1831 - 1879 (Edinburgh)

integral Form of Maxwell's eqns

$$\oint_s \vec{E} \bullet d\vec{a} = \frac{Q_{encl}}{\varepsilon_o}$$

$$\int_s \vec{B} \bullet d\vec{a} = 0$$

$$\int_c \vec{E} \bullet d\vec{l} = -\frac{d\int_s B \bullet d\vec{a}}{dt}$$

$$\int_c \vec{B} \bullet d\vec{l} = \mu_o I_{encl} + \mu_o \varepsilon_o \frac{d\int_s \vec{E} \bullet d\vec{a}}{dt}$$

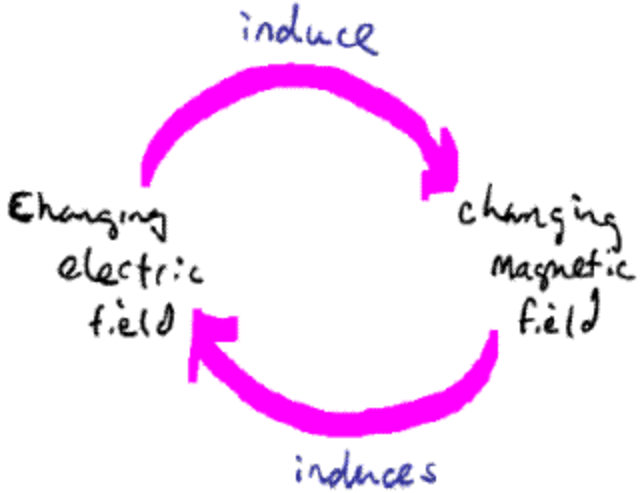
"E" is symbol for electric field

"B" is symbol for Magnetic field

- E, B are "unified" in one framework
  Deeper relationship understood by Einstein

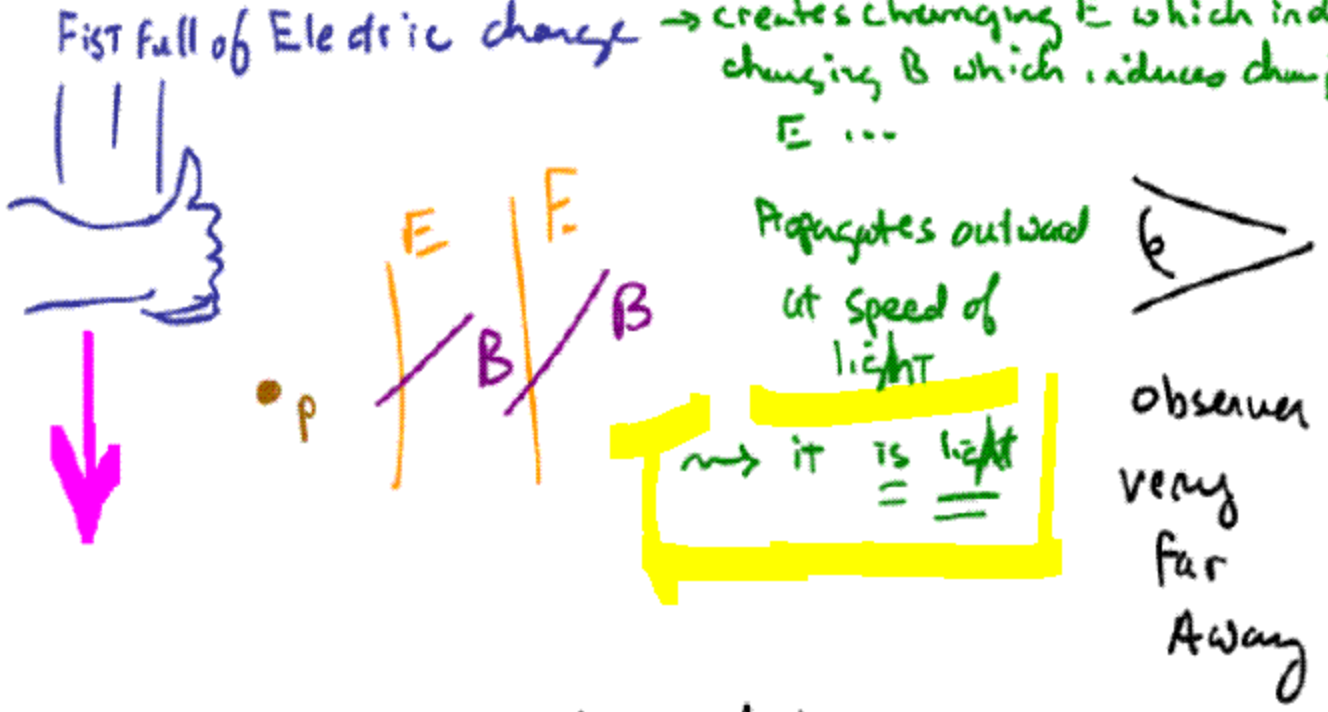
Maxwell unified { Electric / Magnetic } forces

into Electromagnetism



changing E induces changing B
induces changing E
⋮

Propagates out at speed of light!



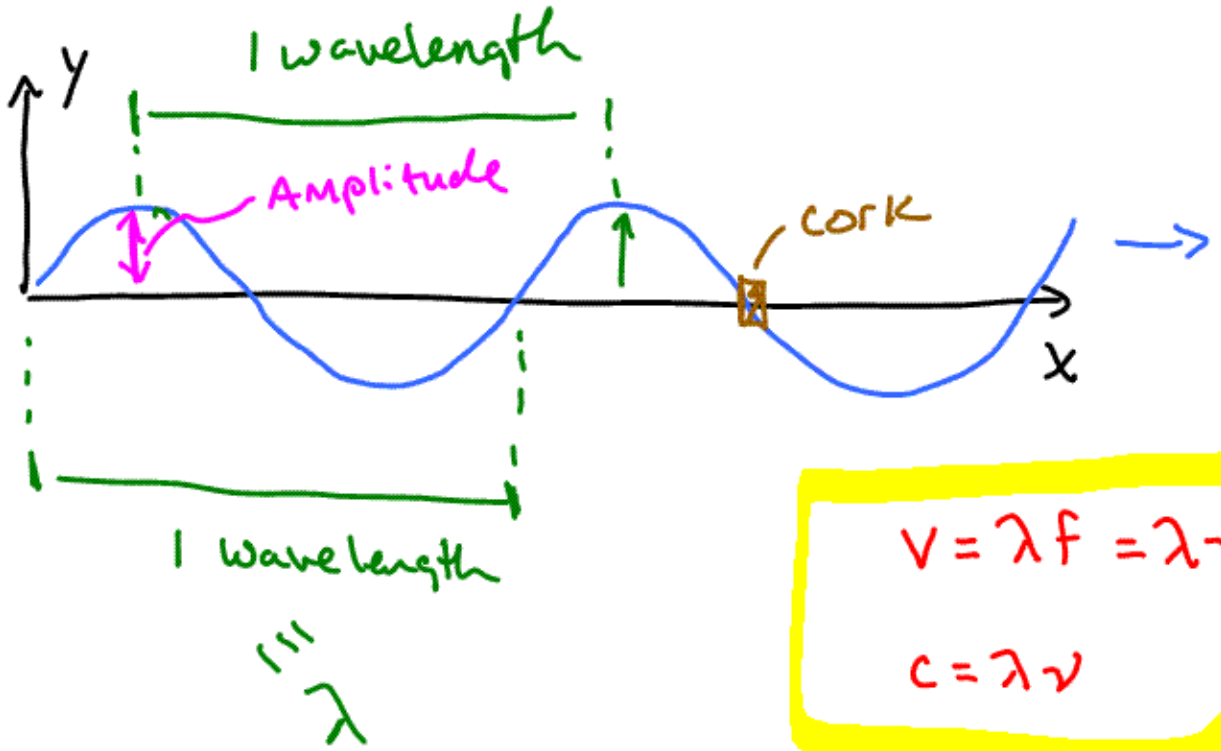
- Maxwell's eqns also tell us that E, B satisfy wave equations

Waves are a well-known mechanical phenomenon

Wave pulse traveling on a string

Waves

Anatomy of Wave



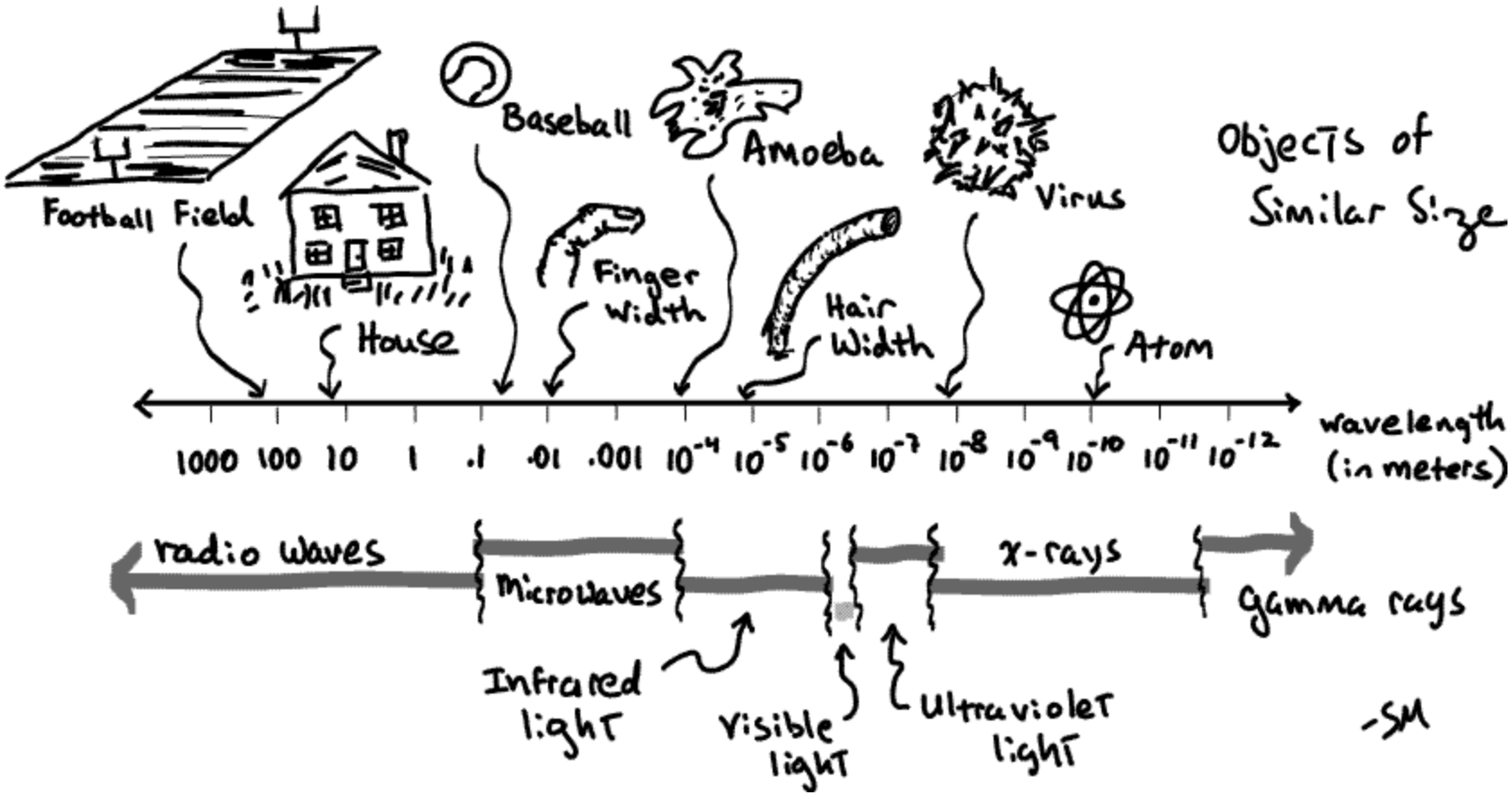
$$v = \lambda f = \lambda \nu$$

$$c = \lambda \nu$$

Period ≡ T of wave is time for "cork" to go through 1 full motion

Frequency ≡ "f" or "ν" ≡ $\frac{1}{T}$ = Hertz
Hz

The variety of electromagnetic Waves



All waves exhibit

→ Interference

Wave Amplitudes Add Together

→ Diffraction

waves spread out when going thru small openings

→ Refraction

Waves bend at interface between substances

java demos – waves

Java applet for waves interfering on string

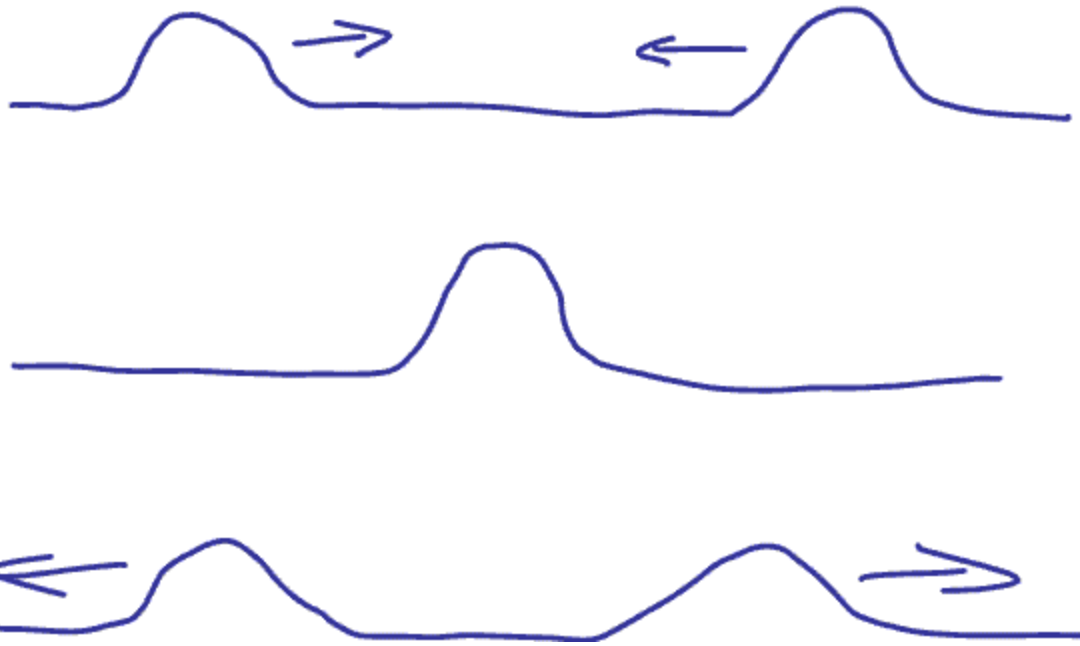
http://mysite.verizon.net/vzeoacw1/wave_interference.html

Superpostion of two waves – beats, standing waves
http://www.kettering.edu/~drussell/Demos/superposition/superposition.html

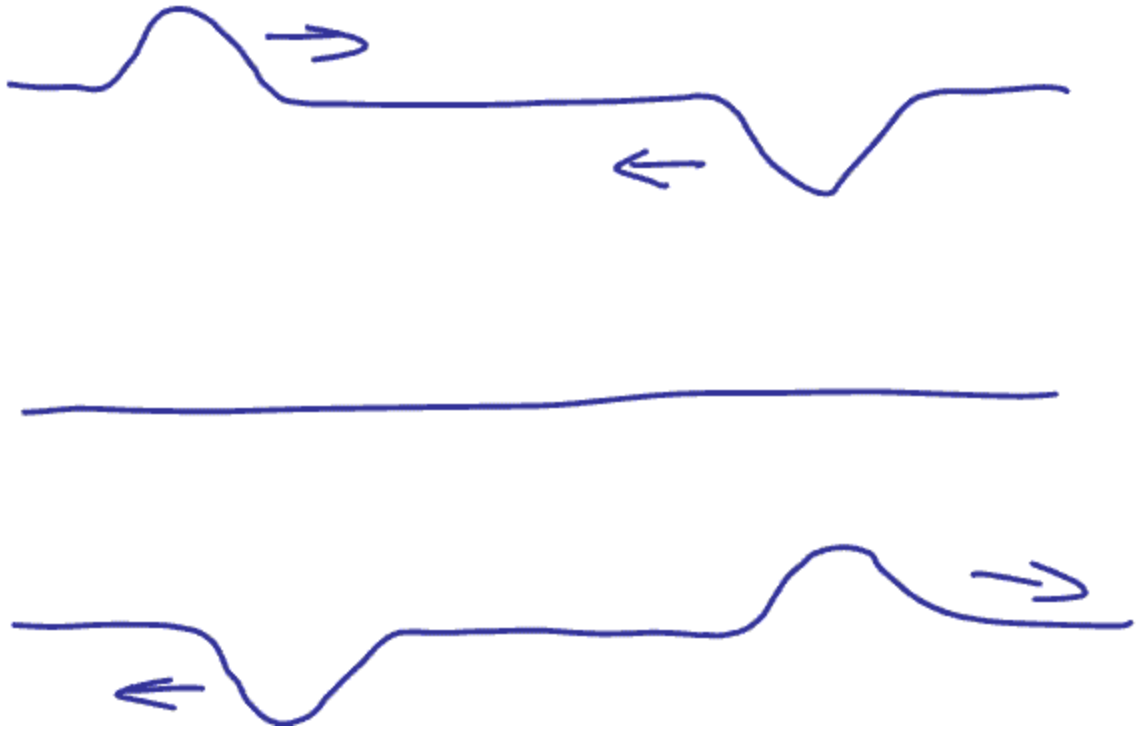
Refraction of light at interface
http://www.physics.uoguelph.ca/applets/Intro_physics/refraction/LightRefract.html

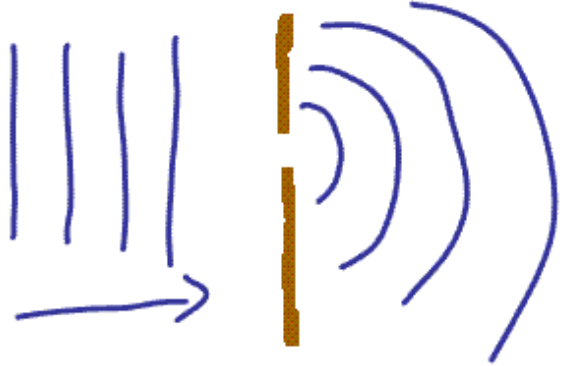
Different frequencies bend different Amounts ... called dispersion

Colliding waves on a string interfere constructively



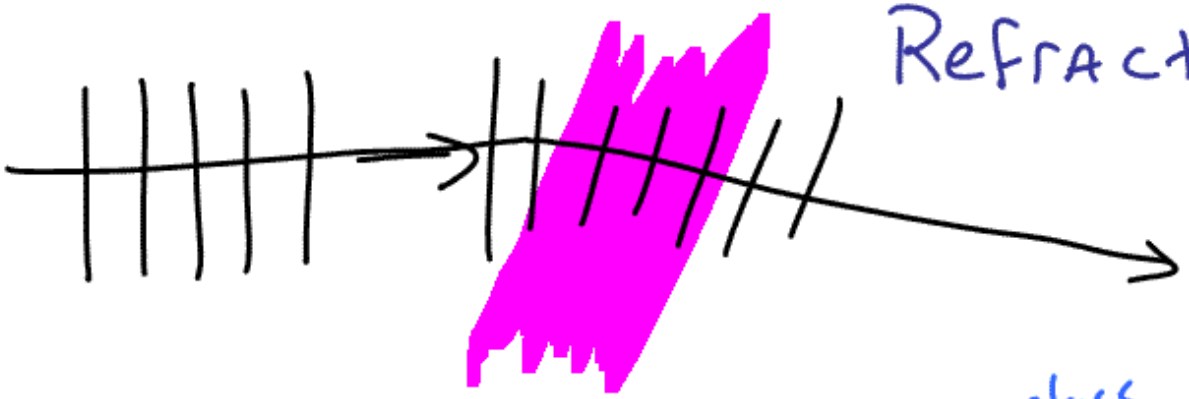
Colliding waves on a string interfere destructively





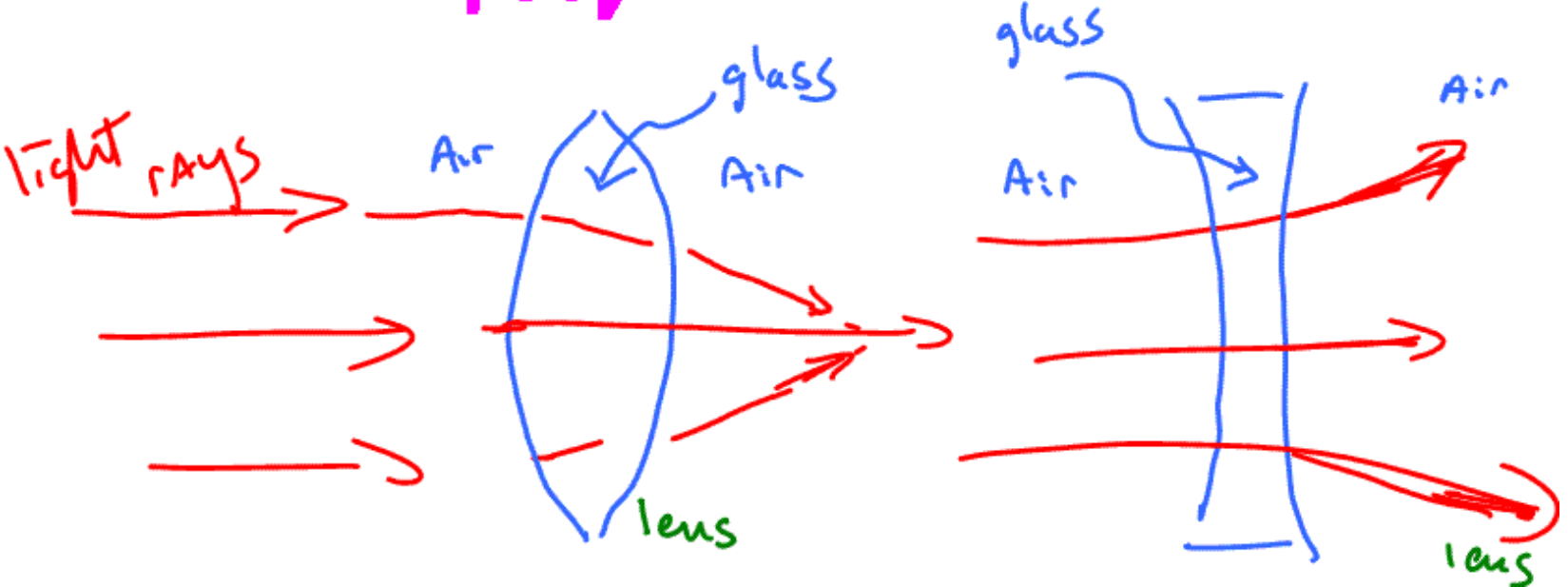
Diffraction

Water waves hit hole in seawall and spread out



Refraction

waves bend at interface between media



light is a wave

Theory well understood

Numerous experiments show light behaves exactly like other wave phenomena such as sound, waves on strings, etc.

Only strangeness is that light is a wave that can travel in a vacuum apparently.

Max Planck

(1858 - 1947)

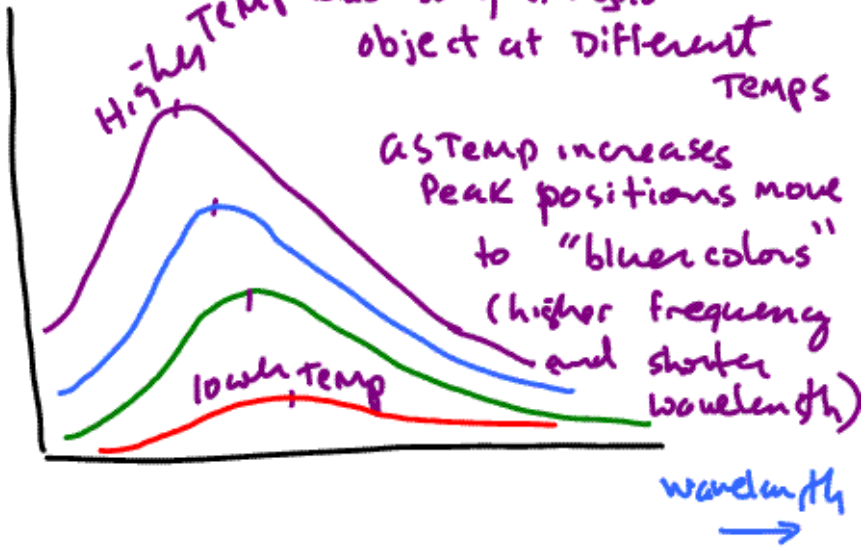
German national

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

observer

"Blackbody" radiation (emitted by object)



Blackbody emission from object at Different Temps

as Temp increases Peak positions move to "bluer colors" (higher frequency and shorter wavelength)

Planck was able to explain blackbody radiation experimental data perfectly

But Assumed light comes in little packets with energy given by

$$E = h\nu$$

↑ CONSTANT found experimentally.

Planck's CONSTANT