Modern Physics aka Quantum Physics *now we really sound smart*

At the end of the 1800s, Physics seemed able to explain any natural phenomenon.

Motion

Light as a Wave

Electromagnetism

Light as electromagnetic waves *see page 48-50 Bodanis*

Problems with the Wave Theory of Light:

At the beginning of the 20th century there were a number of characteristics of light that caused great concern. Light has many characteristics of a wave - it has frequency, wavelength, can diffract and refract, but the wave theory of light could not explain some newer findings...

1. Light has momentum - this is called the Compton Effect. Waves do not. Momentum is a property of matter, not energy.

2. Atomic particles exhibit wave-like abilities. Electrons fired through a thin gap will exhibit a diffraction pattern just like water waves.

3. Neutral atoms are stable. Spinning negative electrons should give off energy (as an em wave) and slowly spiral into the positive nucleus. Why don't they?

4. Roentgen discovered x-rays (1895)

5. A wave can go from any energy level to any other energy level. Light cannot. The energy exists in set ratios only, with no energy existing in between these steps.

Discuss stair analogy of light. Spectrometer with sunlight vs fluorescent light.

6. UV Catastophe!

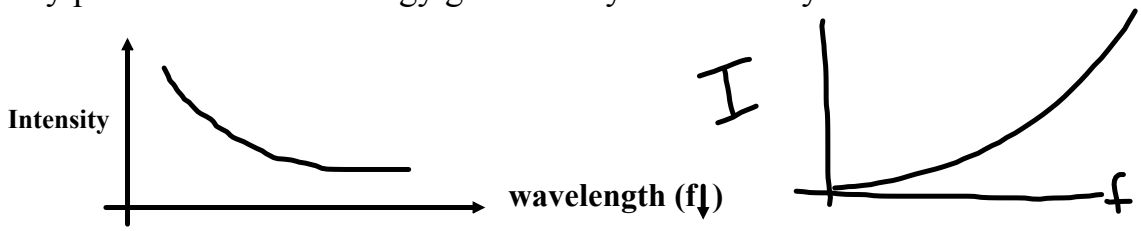
http://www.youtube.com/watch?v=9q0_xxJ825Y&list=PLT87oOLFJv2cKZwA1l7YIlPTie13F2F8T&index=2&safety_mode=true&persist_safety_mode=1&safe=active

http://www.youtube.com/watch?v=SCUnoxJ5pho&safety_mode=true&persist_safety_mode=1&safe=active

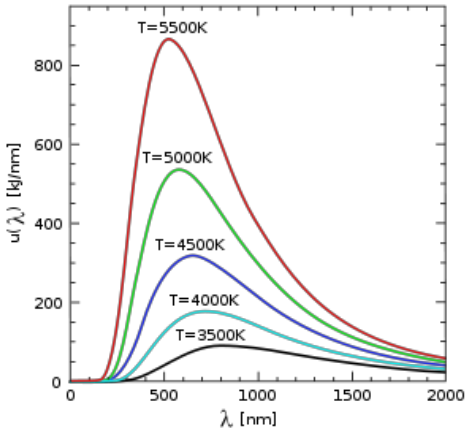
Black Body Radiation

Any opaque body that is above zero degrees Kelvin radiates photons. We can feel this as h
This effect is known as **black body radiation.** Refer to diagram 17.7 p. 699.

Wave theory predicted that the energy given off by a black body would show a curve like t



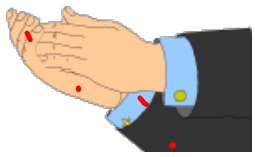
This means that as the wavelength decreased/frequency increased (UV light for example) the energy approaches infinity. This was not observed to happen.



This discovery and its inconsistency with the wave theory of light was called the ***UV catastrophe.*** *So we have another example of a theory (waves) failing to account for the observed results...so it's time to change the theory.*

In 1900, Planck was able to make the observations agree with his theory which was the start of...

quantum physics.



Planck proposed that energy occurs in packets called 'quanta.' In light these packets of energy are called photons.

The energy transferred by light depends on its frequency.

$E = nhf$

n - # of photons
h = Planck's constant 6.626 x 10^{-34} J s
f = frequency

or

$$E = \frac{nhc}{\lambda}$$

$v = f\lambda$

This is the main idea behind quantum theory and was not generally accepted at the time.

Energy increases in 'steps,' not a continuous increase - energy is quantized.

Still does not explain why...?


If you ask me, the speed of light will never change. It just won't...
search ID: mhen127
Planck's Constant Nagging

Ex.1 A laser produces light with a frequency of 4.74×10^{14} Hz. What is the energy of the photons produces by this laser?

Ex.2 What is the energy of a photon that has a wavelength of 6.00×10^{-10} m?

Ex.3 How many photons are emitted from a 1.5 x 10^{-3}W laser each second if the frequency of the laser is 4.75 x 10^{14} Hz?

Ex.4 A 2.0W laser (f = 5.9 x 10^{14} Hz) is used in an eye surgery. How many photons are emitted by this laser if it operates for 0.12s?

Another unit for energy commonly used in quantum physics is the electron volt (eV).

In physics the **electron volt** is a unit of energy equal to 1.602×10^{-19} J. By definition, it is equal to the amount of kinetic energy gained by a single electron when it accelerates through an electric potential difference of one volt (E = qV).

Ex 5 What is the wavelength of a photon that has 1.50eV of energy?