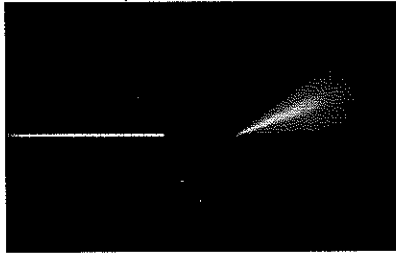


ELECTROMAGNETIC SPECTRUM



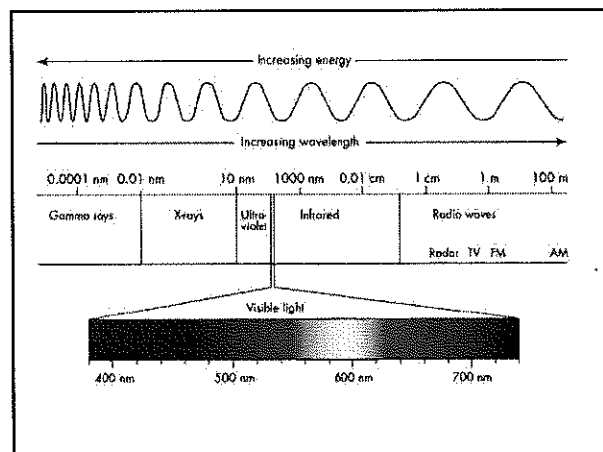
Brief review:

Water and sound waves transfer energy from one place to another- they require a medium through which to travel. They are mechanical waves.

Electric field-region in which charged particles can be pushed or pulled.

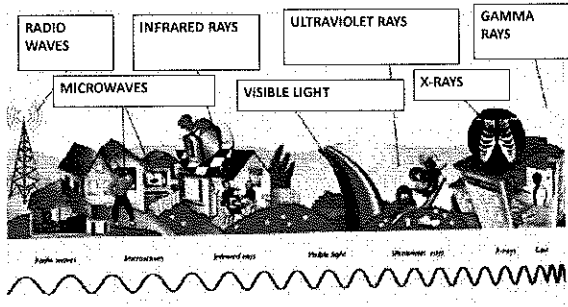
Nature of Electromagnetic Waves

- They are **Transverse waves without a medium.** (They can travel through empty space)
- They travel as **vibrations in electrical and magnetic fields.**
- Have some magnetic and some electrical properties to them.
- Speed of electromagnetic waves = 300,000,000 m/sec = the speed of light in a vacuum.
- Takes light 8 minutes to move from the sun to earth (93 million miles) at this speed.



B. Waves of the Electromagnetic Spectrum

- **Electromagnetic Spectrum**—name for the range of electromagnetic waves when placed in order of increasing frequency
- Click here → (Animation—Size of EMwaves)



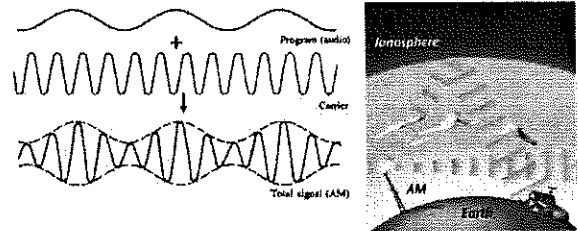
RADIO WAVES

- A. Have the **longest** wavelengths and **lowest** frequencies of all the electromagnetic waves.
- B. A radio picks up radio waves through an antenna and converts it to **sound waves**.
- C. MRI (MAGNETIC RESONANCE IMAGING)

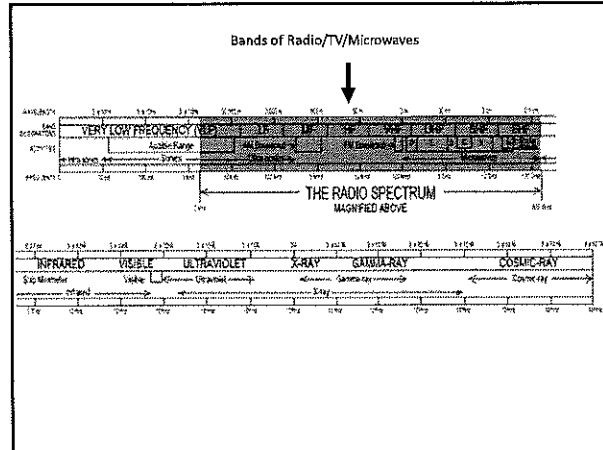
MRI of the Brain



AM=Amplitude modulation—waves bounce off ionosphere can pick up stations from different cities.
(535kHz-1605kHz= vibrate at 535 to 1605 thousand times/second)



FM=Frequency modulation—waves travel in a straight line & through the ionosphere—lose reception when you travel out of range.
 (88MHz-108MHz = vibrate at 88million to 108million times/second)



MICROWAVES

- **Microwaves**—
- Used in microwave ovens.
 - Waves transfer energy to the water in the food causing them to vibrate which in turn transfers energy in the form of heat to the food.
- Used by **cell phones and pagers.**
- **RADAR** (Radio Detection and Ranging)
 - Used to find the speed of an object by sending out radio waves and measuring the time it takes them to return.

INFRARED RAYS

- **infrared**= heat
- You can feel the longest ones as warmth on your skin
- Heat lamps give off infrared waves.
- **Thermogram**—a picture that shows regions of different temperatures in the body.
 - People give off infrared rays

VISIBLE LIGHT

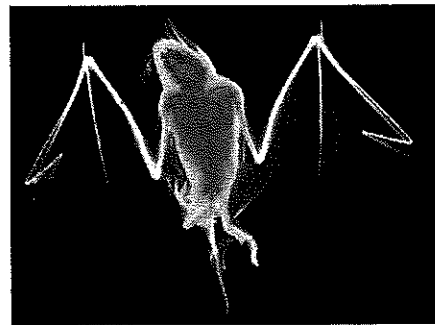
- Electromagnetic waves we **can see**.
- **Longest wavelength= red light**
- **Shortest wavelength= violet (purple) light**
- When light enters a new medium it bends (refracts). Each wavelength bends a different amount allowing white light to separate into it's various colors **ROYGBV**.

ULTRAVIOLET RAYS

- Carry **more energy** than visible light
- Used to **kill bacteria**. (Sterilization of equipment)
- Causes your skin to produce **vitamin D** (good for teeth and bones)
- Too much can cause skin cancer.
- Use sun block to protect against (UV rays)

X- RAYS

- Carry a great amount of energy
- Can penetrate most matter.
- **Bones and teeth absorb** x-rays. (The light part of an x-ray image indicates a place where the x-ray was absorbed)
- Too much exposure **can cause cancer**
 - (lead vest at dentist protects organs from unnecessary exposure)
- Used by **engineers** to check for tiny cracks in structures.
 - The rays pass through the cracks and the cracks appear dark on film.



GAMMA RAYS

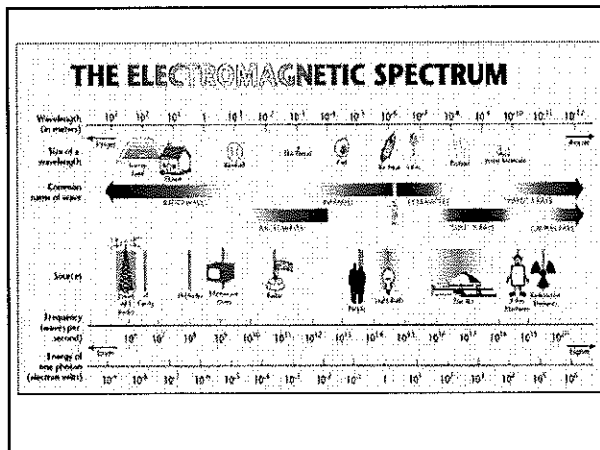
- Shortest wavelength and highest frequency
- Carry the **greatest amount of energy** and penetrate the most.
- Used in **radiation treatment** to kill cancer cells.
- Can be very harmful if not used correctly.



Using the EM waves

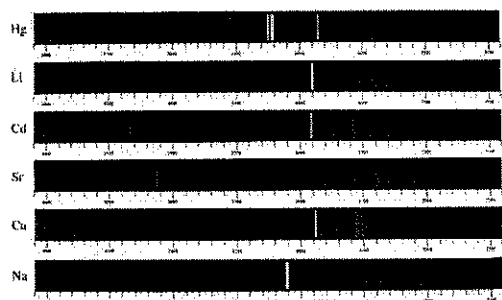
Animation—View a Galaxy at different wavelengths

- Brief SUMMARY
- **A. All electromagnetic waves** travel at the same speed. (300,000,000 meters/second in a vacuum.
- **B. They all have different wavelength and different frequencies.**
 - Long wavelength → lowest frequency
 - Short wavelength → highest frequency
 - The higher the frequency the **higher the energy.**



Spectral Lines

Like a finger print or signature, each element when ignited gives off a unique pattern of spectral lines.



Doppler Effect and Evidence for the Big Bang

EQ: How are the properties of waves used to determine the movement, location of the stars and other bodies in the universe?

<http://www.youtube.com/watch?v=zOEa0ilzgGE&safe=active>

What is the Doppler effect?

“The apparent shift in frequency (and wavelength) caused by the relative motion of a wave source and its observer.”

- When an object that creates a wave moves:
 - Towards the observer the waves are compressed closer together (smaller wavelength).
 - Sound waves become higher pitched.
 - away from the observer the waves are more spread out (larger wavelength).
 - Sound waves become lower pitched.

Demo...

- <http://lectureonline.cl.msu.edu/~mmp/applist/doppler/d.htm>

- Lets hear it:

– <http://www.youtube.com/watch?v=imoxDcn2Sgo>



Click car to hear sound again

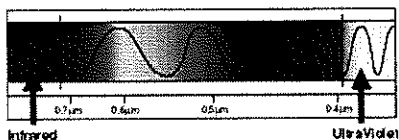
Doppler Effect Interactive

http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::800::600::/sites/dl/free/0072482621/78778/Doppler_Nav.swf::Doppler+Shift+Interactive

Doppler Effect and Light

The Doppler effect holds true for all waves, including electromagnetic (light) waves.

- The light wave of an object moving away from us will have a slightly LONGER wavelength.
- The light wave of an object moving towards us will have a slightly SHORTER wavelength.



How does this help us determine the movement of stars and galaxies?

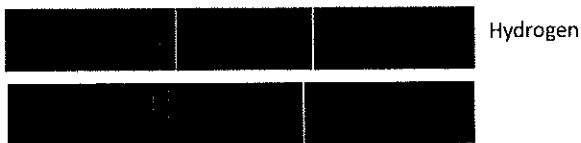
Every element has a spectral signature when burned, you can think of this as an element's fingerprint.



If the object is moving towards or away from the observer, these spectral lines will be "shifted" towards blue, or towards red.

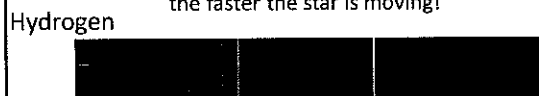
How does this help us determine the movement of stars and galaxies?

What type of shift is this?



Is this object moving towards or away from us?

Remember, the greater the amount of shift, the faster the star is moving!



Hydrogen slightly red shifted. Moving away.



Hydrogen more red shifted. Moving away even faster!

How does this help us determine the movement of stars and galaxies?

We know that stars are made of mostly hydrogen and helium, so astronomers can examine the spectral signature of stars and galaxies to determine which direction it is moving.

- Red shift → Moving away from us
- Blue shift → Moving towards us

Most of the light from stars and galaxies that reaches the earth is red shifted. What does that mean?

It means that everything is moving away from us!

How can everything be moving away from us?

The only explanation for that is

THE UNIVERSE IS EXPANDING!

And if the universe is expanding then long ago it must have been much smaller. The expansion began about 15 billion years ago with the.....

BIG BANG!

