

# PARTICLE PROPERTIES OF WAVES

1. Electromagnetic Waves.
2. Blackbody Radiation.
3. Photoelectric Effect.
4. What is Light?
5. X-Rays.
6. X-ray Diffraction.
7. Compton Effect.
8. Pair Production.
9. Photons and Gravity.

# INTRODUCTION

In our world a wave is a wave and a particle is a particle!!

→ Mechanics of particles.

- Have charge.
- Have mass.
- Have momentum.
- Behave according to the laws of particle mechanics.

→ Optics of waves.

- They exhibit diffraction.
- Interference.
- Polarization.

**In this chapter we will look at things more deeply!!**

# ELECTROMAGNETIC WAVES

James Clerk Maxwell suggested that electric charges generate linked electric and magnetic disturbances that can travel indefinitely through space.

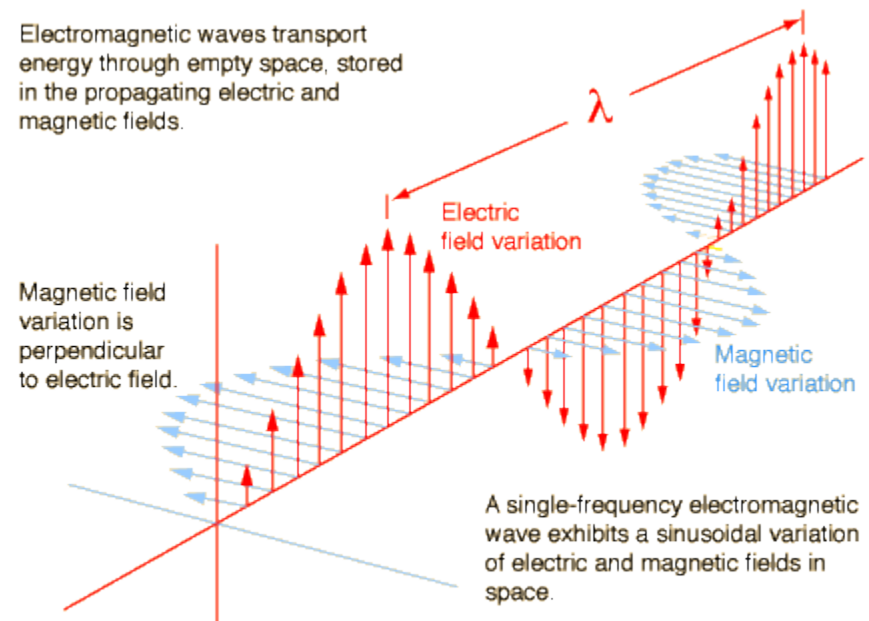
**Watch the two video clips (EM waves)**

$E \perp B$  and both are  $\perp$  to  $v$

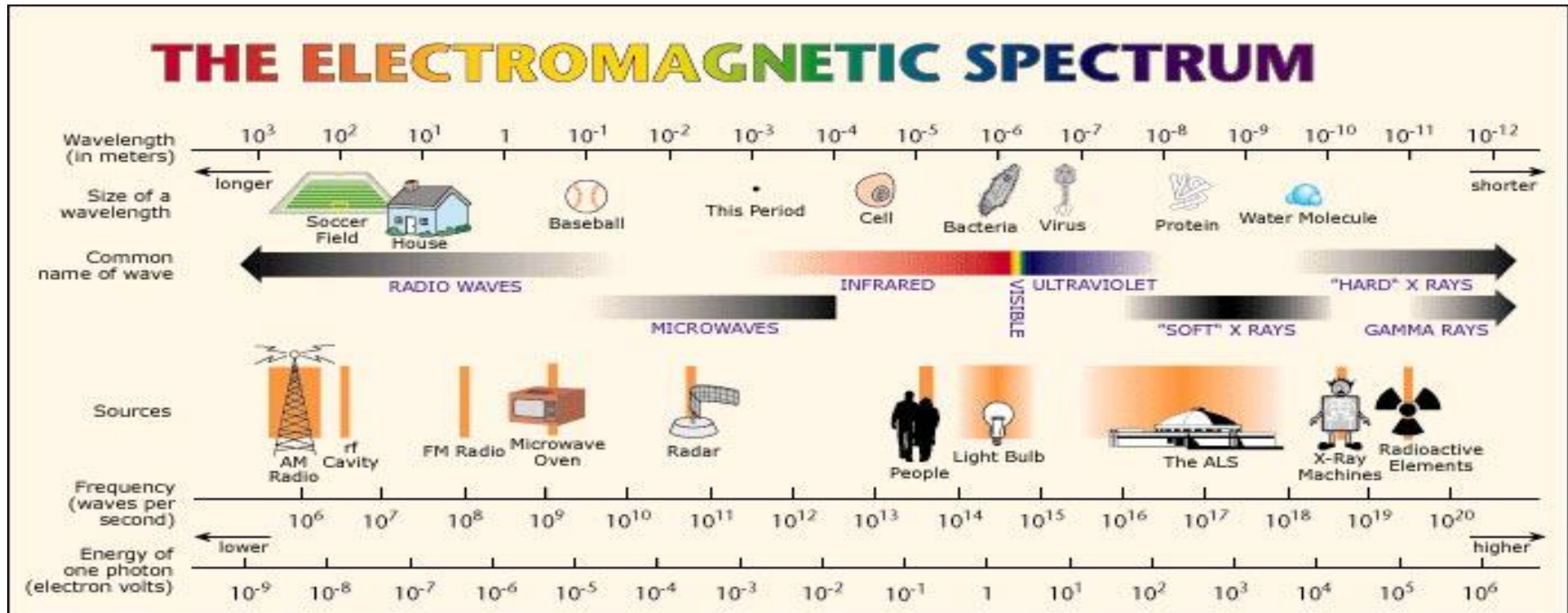
Maxwell showed that the speed  $c$  of EM waves in free space is:

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

Hertz proved it experimentally



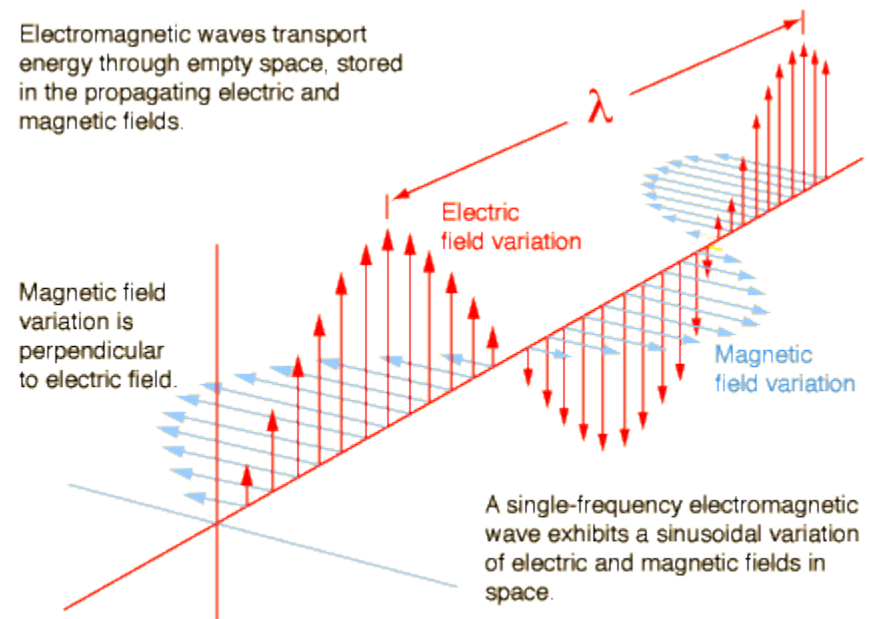
# ELECTROMAGNETIC WAVES



- All EM wave have the same nature but they interact differently with matter depending on their frequencies.
- All obey the **principle of superposition**: *when two or more waves of the same nature travel past a point at the same time, the instantaneous amplitude there is the sum of the instantaneous amplitudes of the individual waves.*

# ELECTROMAGNETIC WAVES

- What does instantaneous amplitude mean?
- What does amplitude mean?
- What is the amplitude of a stretched string, stretched spring, water wave and sound wave?
- What is the amplitude of an EM wave?
  - $E$  ( $E=cB$  but usually  $E$  is used)



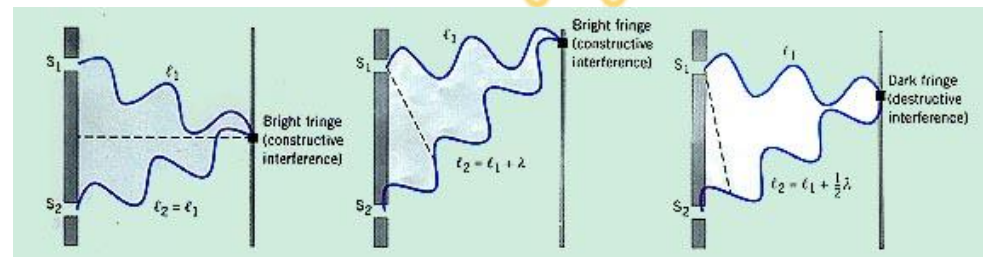
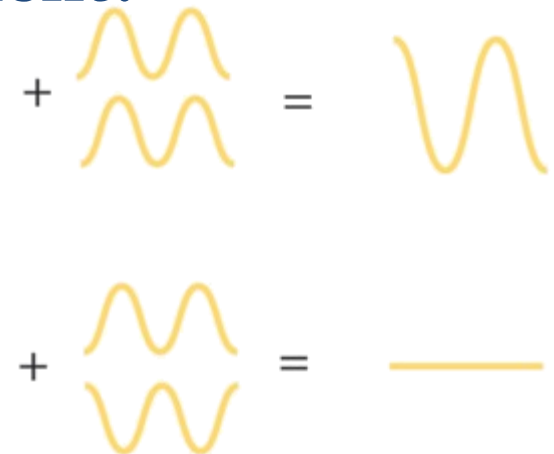
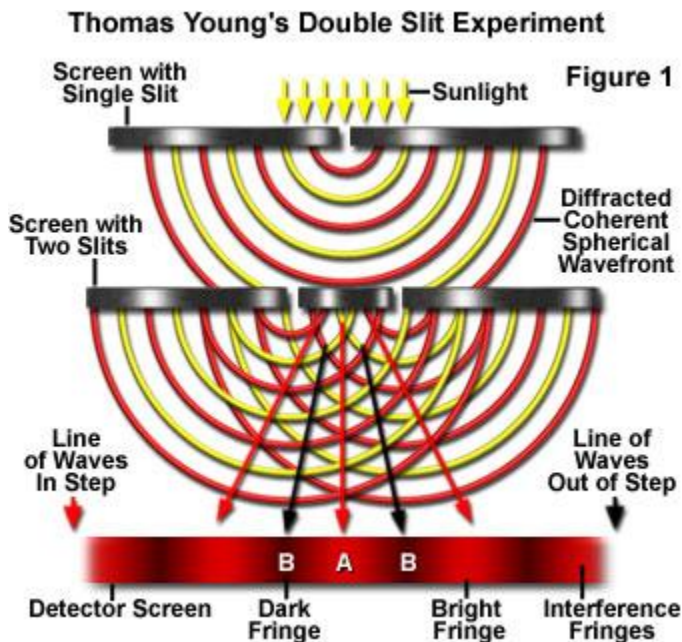
# ELECTROMAGNETIC WAVES

## What are the types of interferences?

- Constructive interference  $\leftarrow \Delta l = \lambda, 2\lambda, 3\lambda, \dots$
- Destructive interference  $\leftarrow \Delta l = \lambda/2, 3\lambda/2, 5\lambda/2, \dots$
- Something in between.

## What is Young's double slit experiment?

## What is diffraction?



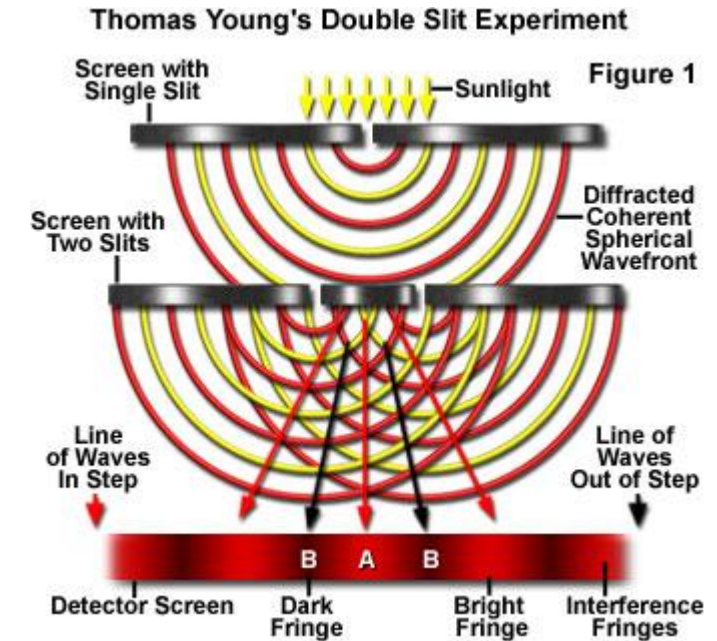
# ELECTROMAGNETIC WAVES

If light consisted of a stream of classical particles, will it behave in the same way?

- Interference and diffraction are found only in waves.
- Young's double slit experiment proves that light consists of waves.
  - Maxwell's theory what kind of wave is light waves: EM waves.

Until the end of the 19<sup>th</sup> century the nature of light seemed settled forever.

And everybody were happy 😊



# ELECTROMAGNETIC WAVES

## Remember....

Coupled electric and magnetic oscillations that move with the speed of light and exhibit typical wave behavior...

Light is an electromagnetic wave...