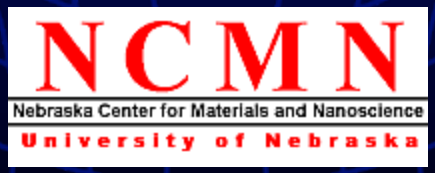
Do Photons Wave?

WhaT is LighT?

CaTch PhoTons

Make PhoTons

Send PhoTons



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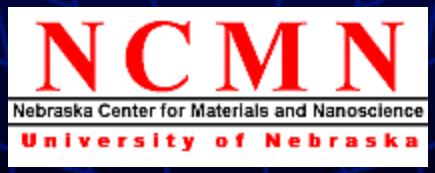


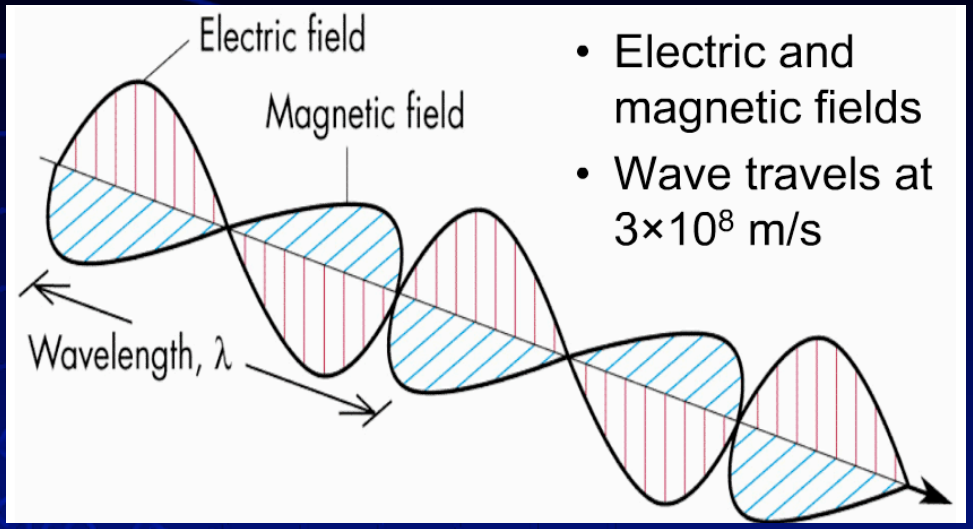
What is Light?

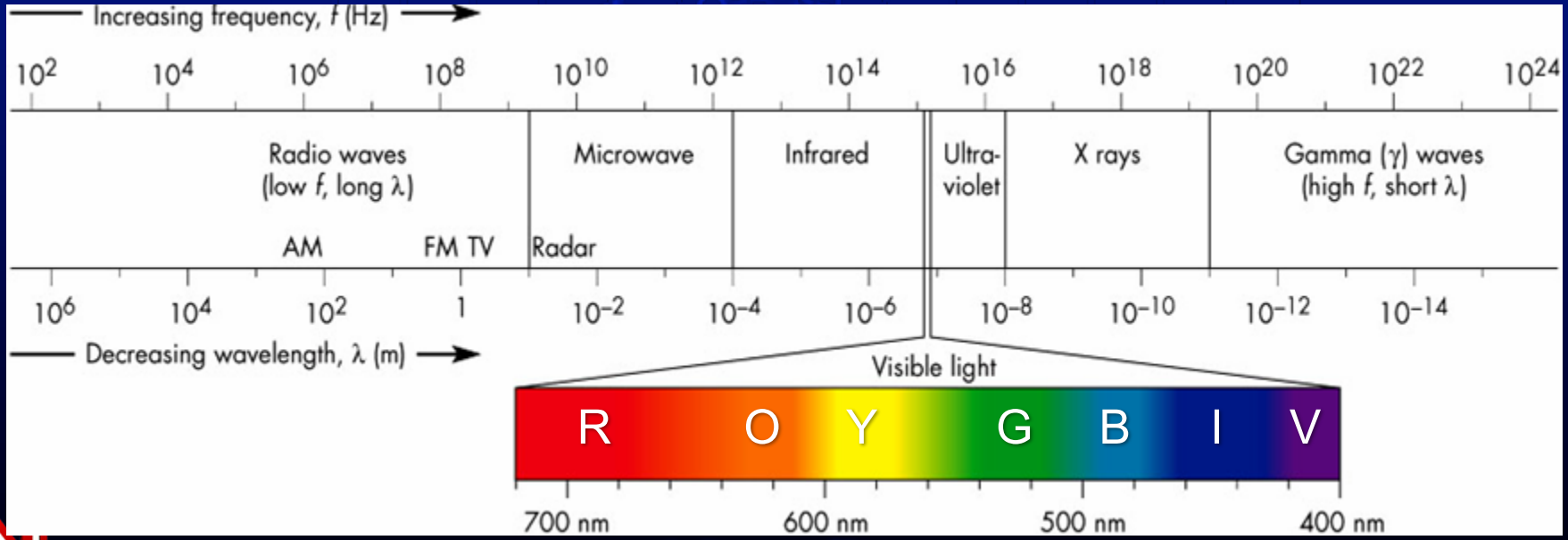
- A Wave--
  - ElecTroMagneTic RadiaTion
  - has Freqyency and WavelengTh
- A ParTicle--
  - is discreTe and 'counTable'
  - has MomenTum and Energy
- Speed = 300,000 km/s

Electromagnetic Waves

- LighT
  - Oscillating ElectroMagnetic Waves
  - Speed: $c = 3.0 \times 10^8$ m/s
  - Frequency and Wavelength:

$$c = f\lambda$$

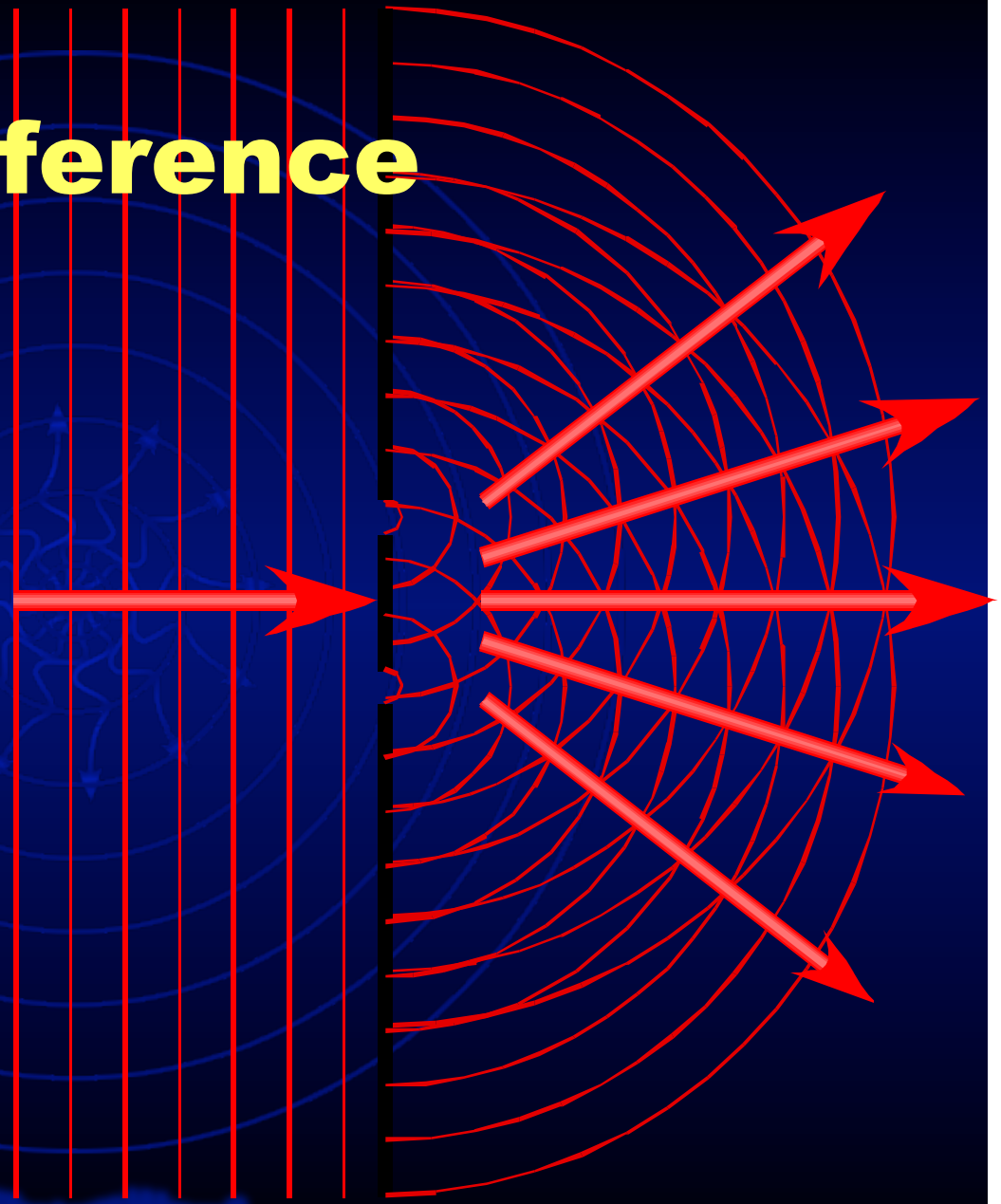




Do Photons Wave?

Interference

- Superposition
  - Constructive
  - Destructive
- Space and Time
  - Node Patterns
  - Beats



Do Photons Wave?

Photons Rule!

- The Universe has, on average:
  - 1 aTom per 5 cubic meTers
  - 400 million phoTons per cubic meTer
- MosT phoTons are 'cold'
  - Average 1/4000 eV each
  - 3 Kelvin microwave background
  - Discovered wiTh a SaTelliTe TV anTenna!

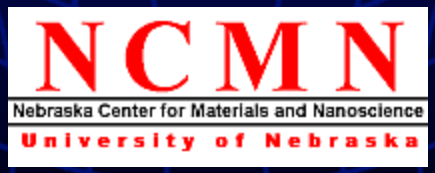
Do Photons Wave?

What is Light?

Catch Photons

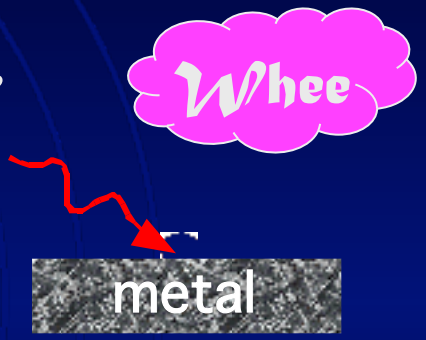
Make Photons

Send Photons



Catch Photons: The Photoelectric Effect

- Photon energy is used to free an electron from a metal



- Explained by Einstein in 1905 (1921 Nobel Prize)

$$E = hf$$

- The other famous equation

$$E = mc^2$$

Do Photons Wave?

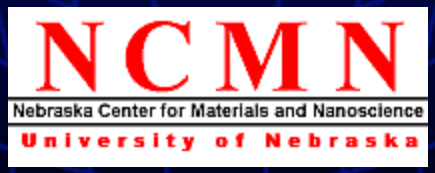
Do Photons Wave?

What is Light?

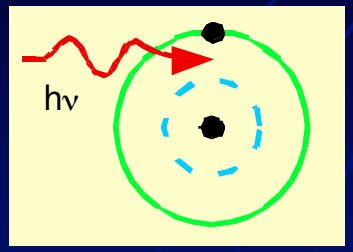
Catch Photons

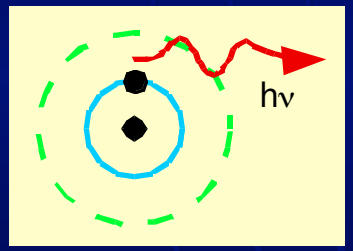
Make Photons

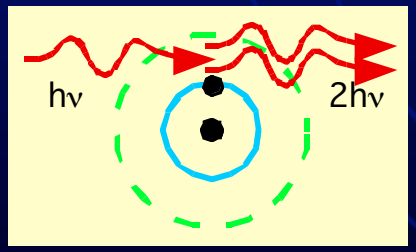
Send Photons



Make Photons:
Light and Atoms





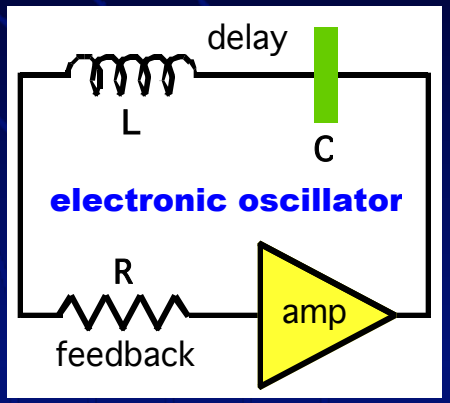


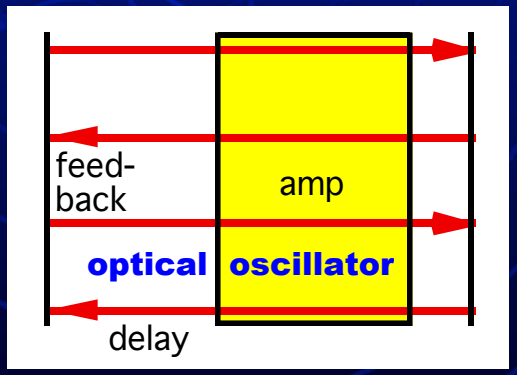
- AbsorpTion
  - phoTon exciTes aTom
- SponTaneous Emission
  - exciTed aTom emiTs phoTon
- sTimulaTed Emission
  - phoTon sTimulaTes exciTed aTom To emiT phoTon (L.A.S.E.R.)

Do Photons Wave?

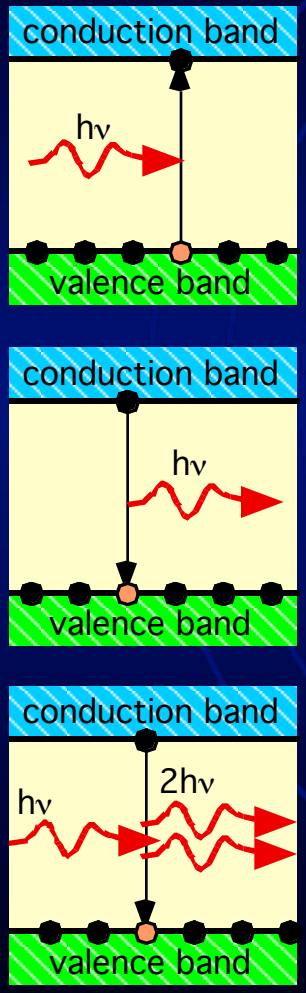
The L.A.S.E.R.

- LighT
- AmpliFicaTion by
- STimulaTed
- Emission of
- RadiaTion





Semiconductor Laser



- Absorption
  - photon excites electron-hole pair (e-h) pair
- Spontaneous Emission
  - e-h pair emits photon
- Stimulated Emission
  - photon stimulates e-h pair to emit photon (L.A.S.E.R.)

Do Photons Wave?

What *IS* a Photon?

a) An Electromagnetic *Wave*

b) An Energetic *Particle*

c) *Both* ('wave-particle duality')

d) *Neither* (we don't really know)

e) Will this be on the *Final?*