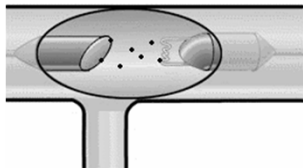


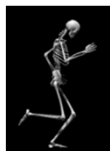
Physics 1161: Lecture 24

X-rays & LASERS

- Section 31-7



X-Rays



Photons with energy in approx range 100eV to 100,000eV.

This large energy means they go right through you (except for your bones).

What are the wavelengths?

X-Ray Production

How do you produce 100 eV photons?

- Black Body Radiation
 - Would require temperature over 10 times hotter than surface of sun
- Excitation of outer electrons
 - Typically have energy around 10 eV
- Radioactive Decays
 - Hard to turn on/off

Electron Tubes

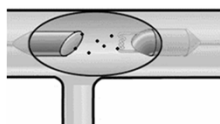
- Accelerate an electron through a voltage difference to give it some energy...

Example

An electron is accelerated through a potential difference of 70,000 V. How much energy does it emerge with?

Recall: $U = qV$

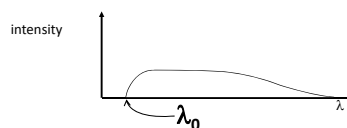
From Electrons to X-Rays



- Now take these high energy electrons (up to 100,000 eV) and slam them into heavy atoms - any element.
- 2 kinds of X-Rays are produced:
 - “Bremsstrahlung”
 - “Characteristic”

Bremsstrahlung X-Rays

- Electron hits atom and slows down, losing kinetic energy.
 - Energy emitted as photon
- Electron hitting atom makes many photons (X-Rays), all with different energy.
 - Many different wavelengths.



- If all of electron's energy is lost to a single photon, photon has maximum energy (minimum wavelength).
 - Minimum X-Ray wavelength = λ_0 .

Example **Bremsstrahlung Practice**

An electron is accelerated through 50,000 volts

What is the minimum wavelength photon it can produce when striking a target?

Minimum wavelength \longleftrightarrow Maximum energy

Electron loses ALL of its energy in one collision and emits one photon.

Characteristic X-Rays

Electron knocks one of the two K shell (ground state) electrons out of an atom.

L (n=2) or higher shell electron falls down to K shell (ground state) and x-ray photon is emitted

Characteristic x-ray nomenclature

- n=1 "K shell"
- n=2 "L shell"
- n=3 "M shell"

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K_{β} X-Rays

K_{α} X-rays come from n=2 \rightarrow n=1 transition.

What about n=3 \rightarrow n=1 transition?

Not as likely, but possible. Produces K_{β} X-Rays!

K_{β} X-Rays are higher energy (lower λ) than K_{α} . (and lower intensity)

Different elements have different Characteristic X-Rays

All Together Now...

Bremsstrahlung X-Rays and Characteristic X-Rays both occur at the same time.

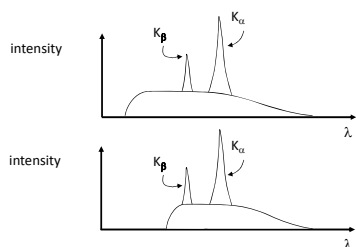
X-Rays Checkpoint

These two plots correspond to X-Ray tubes that:

- (1) Are operating at different voltages
- (2) Contain different elements
- (3) Both
- (4) Neither

Which graph corresponds to the tube being operated at the higher voltage?

1. Top
2. Bottom

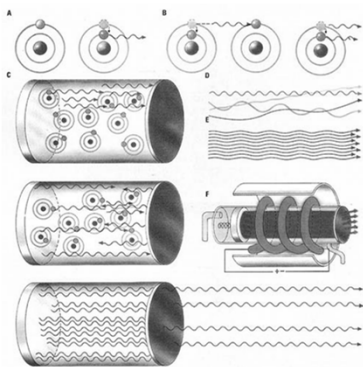


LASER

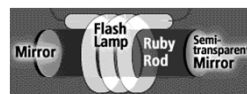
A device which produces light or some other form of electromagnetic radiation that is monochromatic (of a single wavelength), coherent (in step), and contained in narrow beam

- L
- A
- S
- E
- R

Laser Operation



Laser



- A laser is a device that creates and amplifies a narrow, intense beam of coherent light.

- In a ruby laser, light from the flash lamp, in what is called "optical pumping", excites the molecules in the ruby rod, and they bounce back and forth between two mirrors until coherent light escapes from the cavity.