University of Virginia

Department of Physics

Physics 606: How Things Work II

Lecture #39 Slides:

Medical Imaging and Radiation

Medical Imaging and Radiation

Question:

X rays have trouble going through lead because

1. lead is a metal
2. lead is heavy
3. lead atoms have many electrons
4. lead is a hard material

Observations About Medical Imaging and Radiation

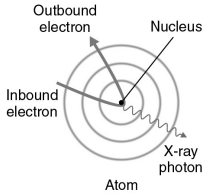
- They manage to work right through your skin
- Imaging involves radiation of various sorts
- Some imaging radiation is itself hazardous
- Radiation can directly make you well, sick, or neither
- Some radiation involves radioactivity
- Some radiation involves accelerators

X rays

- Short-wavelength electromagnetic waves
- An x-ray photon has lots of energy
  - Enough to do much chemical damage to molecules
  - Enough to knock particles out of atoms
- Produced by energetic events
  - Rapid acceleration of a charge
  - Radiative transition in a highly excited atom

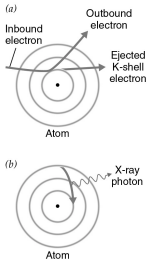
Bremsstrahlung X rays

- When a fast-moving electron swings around a heavy nucleus, it accelerates rapidly
- Electron emits much of its energy as X-ray photon



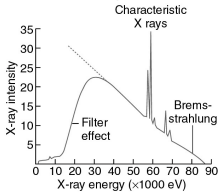
Characteristic X-rays

- When a colliding electron excites an atom to high-energy state, that atom can then radiate an x-ray photon



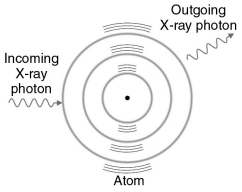
Producing X-rays

- Accelerate electrons to 10kV - 100kV
- Let electrons hit heavy atoms
- Some x-rays emitted via bremsstrahlung and some as characteristic X rays
- X-ray tube filters away lowest energy photons, which is good because they're useless and burn



X rays and Matter

- X rays interact with atoms
  - Rayleigh scattering
  - Photoelectric effect
- Rayleigh scattering makes the sky blue and deflects X rays



Photoelectric Effect

- X ray causes radiative transition in an atom and ejects an electron
- Electron's energy is the difference between the x-ray photon's energy and the energy needed to remove electron from atom
- Effect is most likely when electron energy is low
- Effect is strongest in many-electron atoms