Radiation physics-theoretical
Lec.4: **X-Ray production**

Asst.Lec.Dumoaa Haider Shakir

Properties Of X-ray

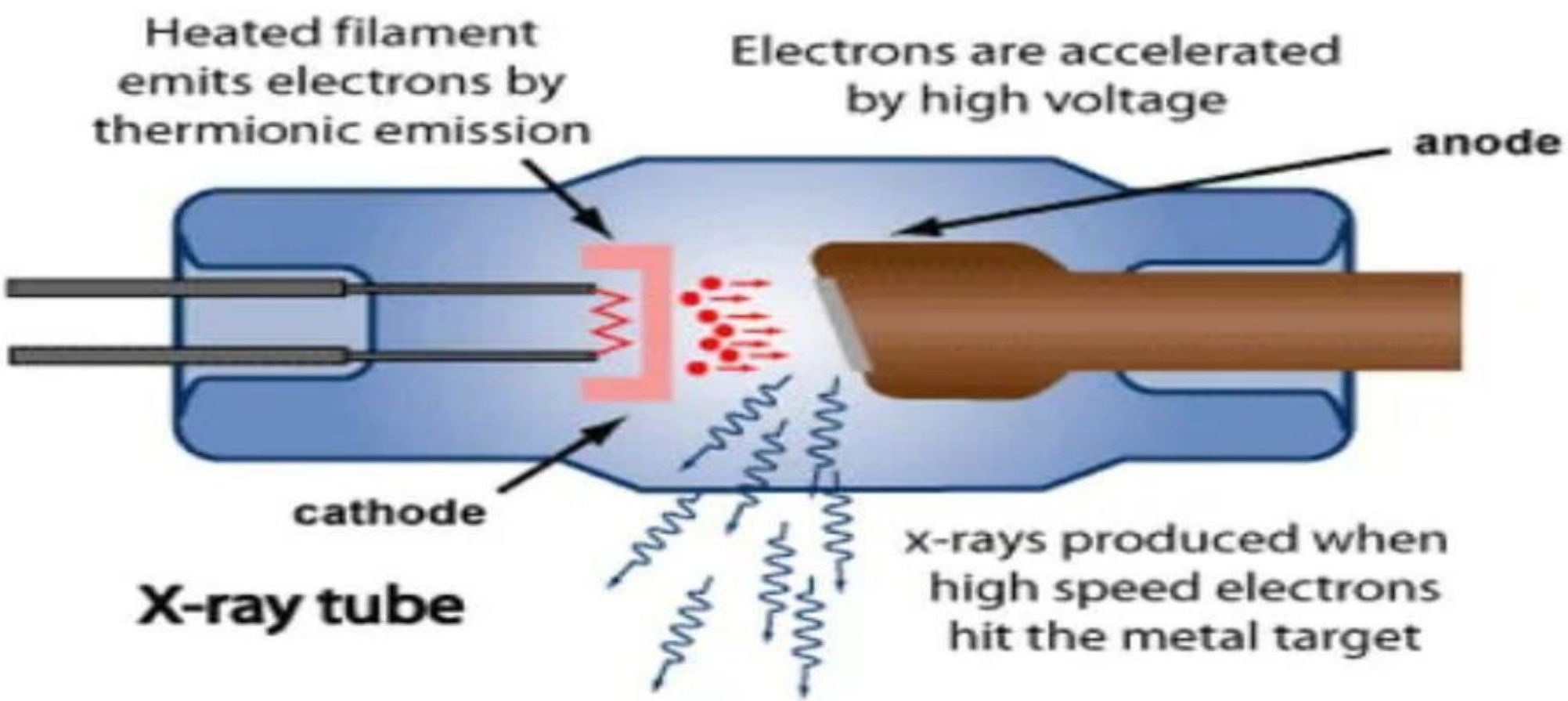
- X-rays are invisible.
- X-rays have no mass.
- X-rays travel at the speed of light in a vacuum
- X-rays travel in straight lines.
- They have a very short wave length and high frequency.
- They are unaffected by electric and magnetic fields
- They are transmitted by (pass through) healthy body tissue, They are absorbed (stopped) by metal and bone
- They can cause photoelectric emission
- They are produced when a beam of high-energy electrons strike a metal target

These properties make X-rays very useful for medical diagnosis and treatment.

Production Of X-rays

- When an electric current passes, the filament heats up due to the phenomenon of thermionic emission
- Electrons from (cathode) the filament are accelerated onto a target (anode).
- The source of electrons is the cathode, or negative electrode .Electrons are stopped or decelerated by the anode, or positive electrode. Electrons move between the cathode and the anode because there is a potential difference in charge between the electrodes.
- When the electrons are suddenly decelerated on impact, some of the kinetic energy is converted into EM energy, as X-rays.
- Less than 1 % of the energy supplied is converted into X-radiation during this process. and 99 % heat .

PRODUCTION OF X-RAY



Thermionic Emission

- When current flows through filament , it becomes heated and its atoms absorb thermal energy.
- Some electrons acquire enough energy to allow them to move from the surface of the metal.
- This emission of electrons resulting from the absorption of thermal energy is referred to as thermionic emission.

Production Of X-rays

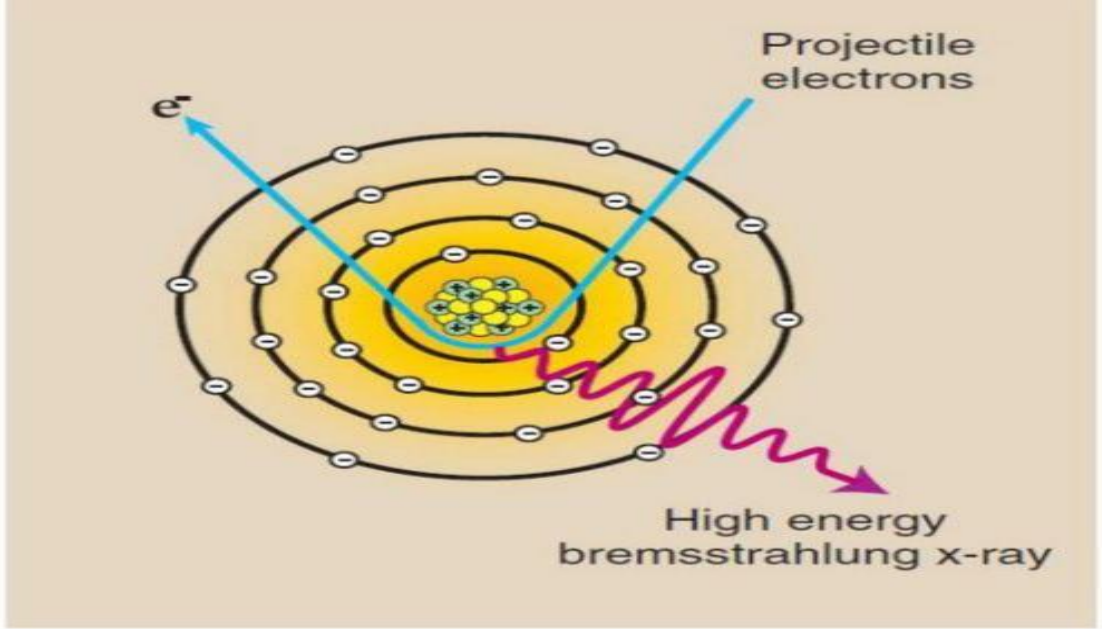
The kinetic energy of electrons in the tube produce by the flow of current is converted into x-ray photons at the focal spot of an X-ray tube by two mechanisms.

1. **Bremsstrahlung radiation**
2. **Characteristic radiation**

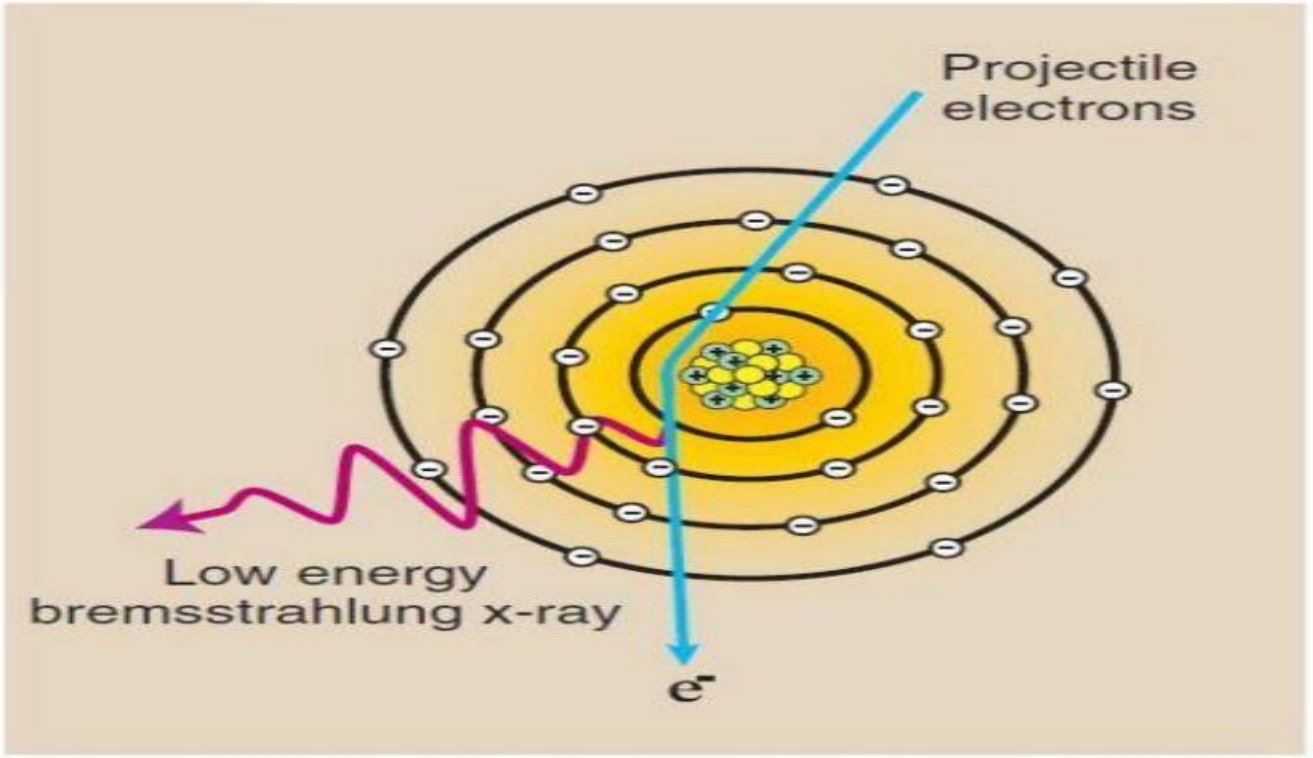
Bremsstrahlung Radiation

Bremsstrahlung radiation, the primary source of X-ray photons from an X-ray tube, is produced by

1.Direct hit of electron on nucleus in target - during this type of collision all the kinetic energy of high speed electron will be converted into single X-ray photon with maximum energy.

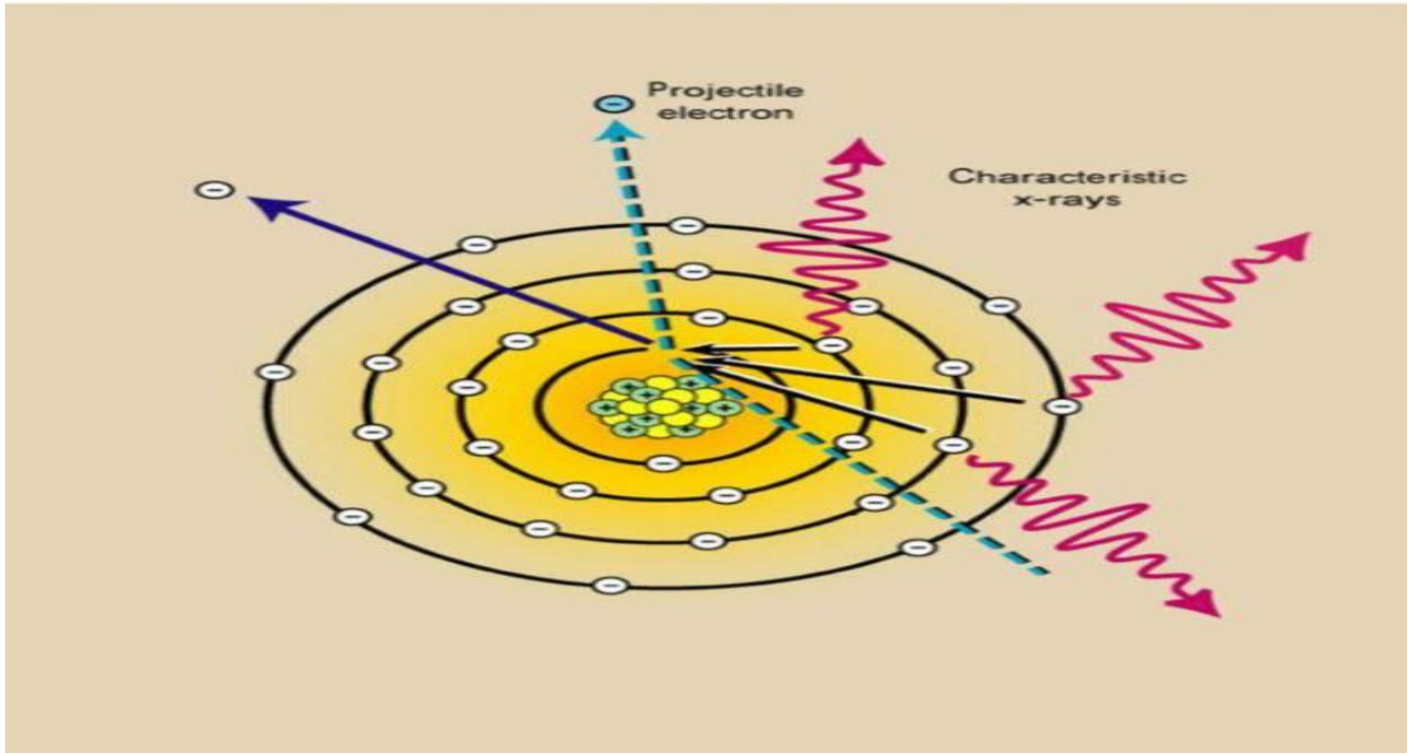


2. By passage of electron near nucleus, which results in electron being deflected and decelerated. This deceleration causes it to lose some of its kinetic energy. This energy is given off in the form of a photon of electromagnetic radiation, which has an energy equal to that lost by the deflected electron i.e. photon of lower energy



characteristic Radiation:

Characteristic radiation occurs when bombarding electron of the tube current displaces an electron from a shell of a target atom, there by ionizing the atom. Incident electron ejects photoelectron from inner orbit, creating vacancy. Inner vacancy is filled with electron from outer orbit.



Spectrum of X-ray

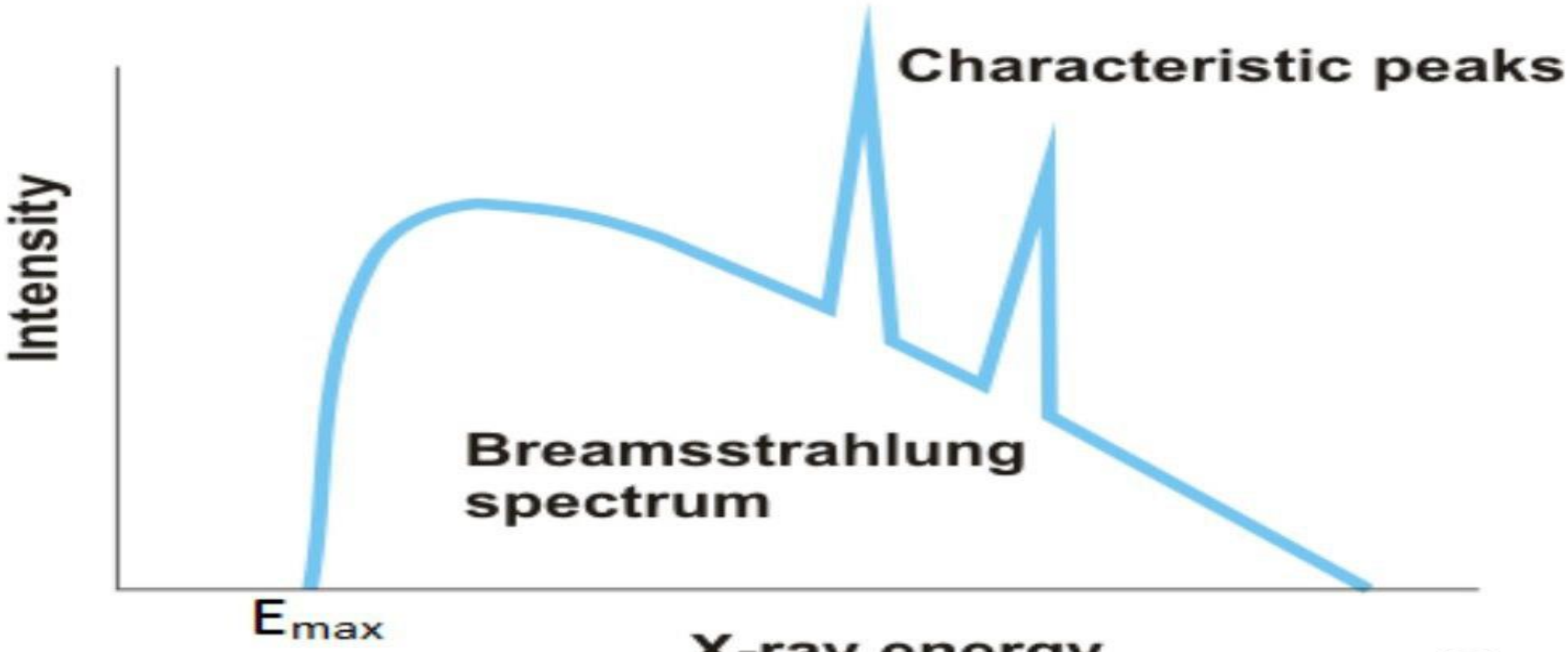
there are two types of spectrum

Continuous X-ray Spectrum

- Bremsstrahlung X-rays can be produced at any projectile electron energy. In diagnostic radiography most of the x-rays are Bremsstrahlung x-rays.
- The Bremsstrahlung x-ray energies range from zero to a peak and back to zero.
- This is referred to as the Continuous X-ray Spectrum.
- The majority of the useful x-rays are in the continuous spectrum.
- The maximum energy will be equal to the kVp of operation.
- This is why it is called kVp (peak).

Characteristic X-ray Spectra

- Different target materials give different wavelengths for the peaks in the X-ray spectra.
- The peaks are due to electrons knock out inner-shell electrons from target atoms.
- When these inner-shell vacancies are refilled by free electrons, X-ray photons are emitted.
- The peaks for any target element define its characteristic X-ray spectrum.



X-ray spectrum