Al-Mustaqbal University Colleg
Medical Physics Department

Medical Imaging

Lecture 3

Physics of X-Ray

Second Stage

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Introduction to X-Ray

- ✓ X- ray is electromagnetic radiation with short wavelength of 10^{-10}m and high frequency of 10^{18} Hz, which is able to pass through many materials.
- ✓ In 1895, Wilhelm Roentgen, a German discovered X-rays, when he was investigating the conduction of electricity through gases at low pressure in glass tubes.
- ✓ He noticed that the positive electrodes in the tubes gave off invisible rays which made fluorescent screens (Barium platinocyanide screen kept near the tube) to glow and fogged photographic plates.
- ✓ The rays were highly penetrating, they passed through black paper and even thicker objects. They were not deflected in magnetic field.
- ✓ Therefore, Roentgen concluded that they were not charged particles. As their nature was not known he called them X-rays; later, they were shown to be electromagnetic radiation of very short wavelength.
- ✓ The first use of X-rays was in medical diagnosis by Henri Becquerel within six months of their discovery in 1895.

Properties of X-Ray

1. X-rays are electromagnetic radiation of shorter wavelength (few nm).
2. They travel in straight line with a velocity equal to light.
3. X-rays are not influenced by electric and magnetic fields.
4. X-rays penetrate through substances that are opaque to visible light.
5. X-rays produce fluorescence in materials like calcium tungstate, and cesium iodide, etc.
6. X-rays affect the photographic film and form latent image.

7. X-rays produce ionization and excitation in the substances through which they pass.

8. X-rays produce chemical changes in substances through which they pass.

9. X-rays produce biological effects in living organisms. The cells can be either damaged or killed due to X-ray exposure

Uses of X-Ray

- Medical image: X-rays are used to view images of the different parts in the human body (Uses in medical images) because that the X-rays penetrate different materials.
- Radiation therapy: X-rays play an important role in the fight cancer, with high energy radiation used to kill cancer cells.
- Airport security: x-ray security system that scans baggage to check for dangerous items and full body x-ray scans.

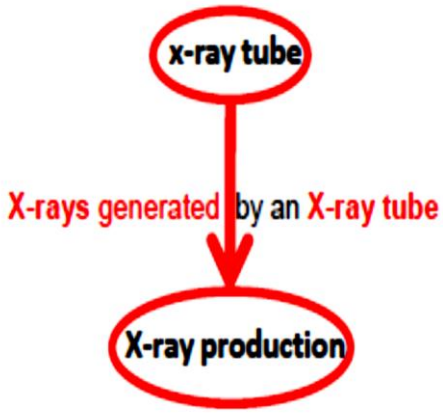
Components of X-ray generator

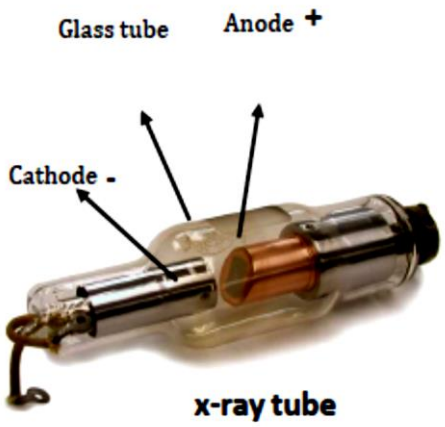
- The x-ray tube is an electrical device used for generation of X-ray, which consist from many parts:

  (i) ***Glass tube:*** It is a vacuum glass tube (Pyrex glass) that contains the anode and cathode.

  (ii) ***Cathode***: It consists of a tungsten wire that has a high melting point of 3410 °C

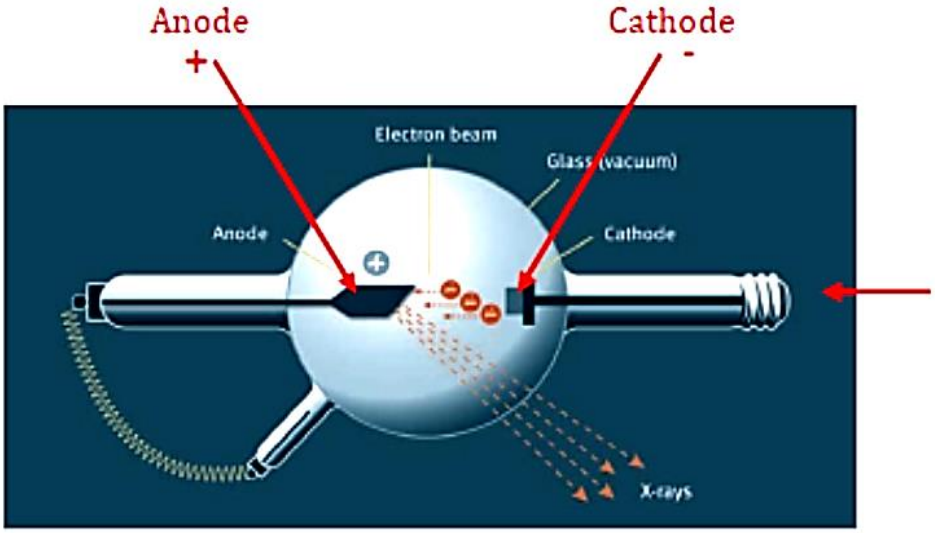
  (iii) ***Anode***: It is a copper rod made with a tilted surface.





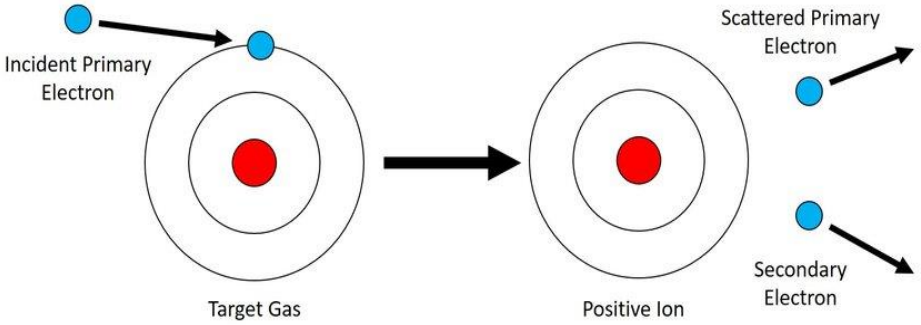
Generate X-rays

- When the current passes through cathode (tungsten wire), the temperature in the cathode will increase so that it can release electrons towards the anode.
- Therefore, according to the excited-state atom; X-rays are generated from the interaction of the high-energy electrons that come from the cathode and then anode.



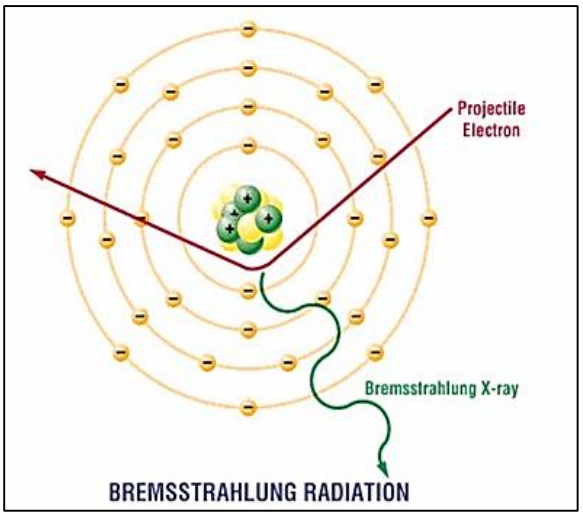
When the electron arrives at the target, it interacts in four ways as follows:

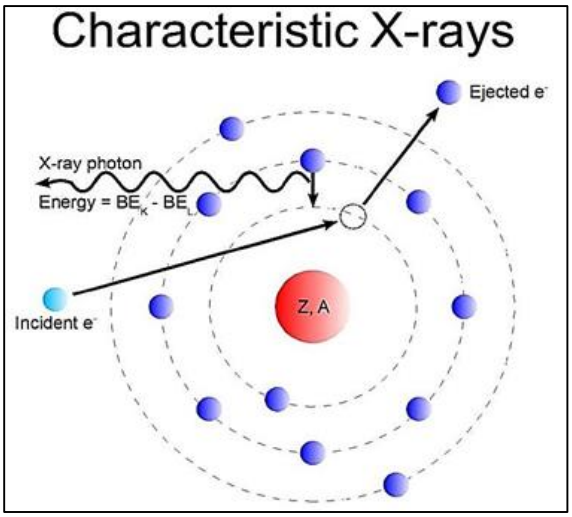
(A) ***Ionization of target atoms***: a beam electron knocks an electron out of a target atom, resulting in a positive ion, secondary electron, and scattered electron.



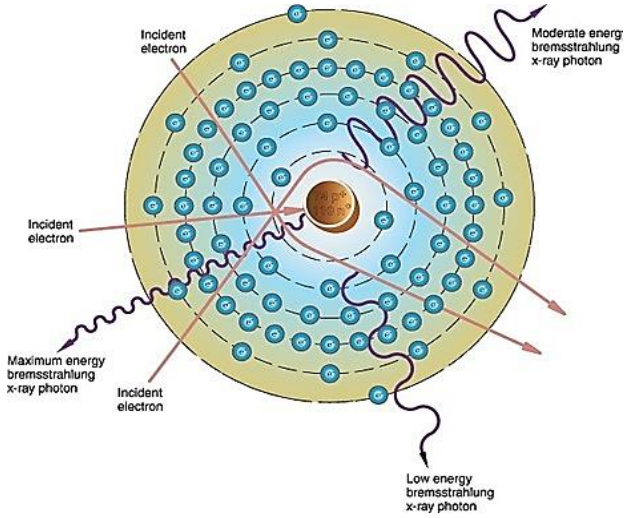
(B) ***Characteristic X-rays***: This is an interaction between the incident electron and the electron in the K shell.

(C) ***Interaction with nuclear field***: The incident electron occasionally reaches nearer to nucleus of an atom in the target. The loss of energy appears in the form of X-ray photons, continuous spectrum known as Bremsstrahlung.





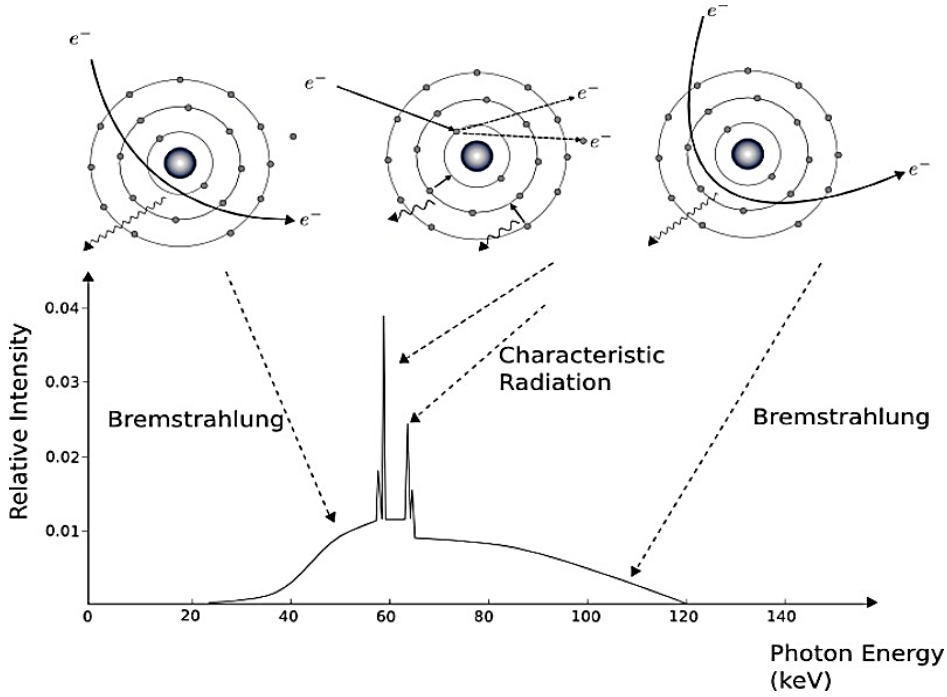
(D) ***Interaction with nucleus***: The electron may hit the nucleus directly and is stopped completely in a single collision. The entire electron energy appears as bremsstrahlung radiation.



X-ray spectra

There are two types of X-ray spectrum:

1. ***continuous spectrum*** 2. ***characteristic spectrum***



- ✓ ***A bremsstrahlung*** spectrum consists of X-ray photons of all energies up to maximum in a continuous fashion, which is also known as white radiation, because of its similarity to white light.
- ✓ ***A characteristic*** spectrum consists of X-ray photons of few energy, which is also called as line spectrum.
- ✓ The position of the characteristic radiation depends upon the atomic number of the target.

Factor affecting on x-ray spectra

The X-ray spectrum is influenced by:

1. Applied voltage.
2. Target material.
3. Tube current.
4. Exposure time.
5. bremsstrahlung process and filtration.

Types of radiography using X-rays

(1) Plain X-rays

(2) Computed Tomography (CT)

(3) Fluoroscopy

(4) Mammography

(5) Angiography