Al-Mustaqbal University
College of Science
Department of Medical Physics
The Fourth Stage
First Course

Radiation Protection

LECTURE EIGHT

X Rays, X-Ray Regulations, Basic Nuclear Physics

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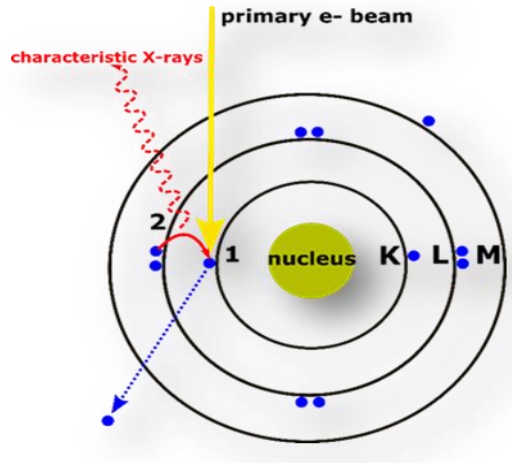

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LECTURE EIGHT: X– Rays and Basic Nuclear Physics

- **X-Ray**
- **Properties of X-Ray**
- **Production of X-Ray**
  - **Bremsstrahlung " braking radiation "**
  - **Characteristic X-ray**
- **X-Ray Regulations**

❑ **X-rays** are a form of electromagnetic radiation that has a higher energy and can pass through most objects, including the body

❑ **Properties of X-Ray**

- X-ray is a type of electromagnetic radiation with frequency of 10^{18} Hz and wavelength of 10^{-10} m (high frequency and very short wavelength).
- X-ray has the ability to pass through liquids, solids, gases and many materials.
- X-ray is traveling in a straight line.
- X-ray is invisible to the eye.
- Long x-ray exposure can be harmful to living organisms, and short exposure to x-rays is not harmful.
- X-rays can be a very dangerous type of radiation because they have a high frequency and high energy.
- When x-rays hit the material, electrons of this material will be ejected from the atom leaving behind a positive charge. For this reason, x-ray radiation is sometimes known as ionizing radiation.

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❑ Production of X-Ray Beams

There are various atomic processes that can produce X-ray photons, and they all occur in the heavy atoms of tungsten.

One : Bremsstrahlung "braking radiation."

Two : Characteristic X-ray.

They can both occur in the heavy atoms of tungsten. X-rays are photons of electromagnetic radiation produced when a target of heavy metal (Tungsten is often the material chosen for the target or anode of the x-ray tube) is struck by electrons traveling at high speed. It is difficult to accelerate the electrons in air, so the process has to be curried in vacuum. Only about 1 % of the electrons produce an X-ray photon; the rest is lost in heating up the target.

One : Bremsstrahlung "braking radiation."

Braking radiation is produced when a high-speed electron interacts with a nucleus, as follows:

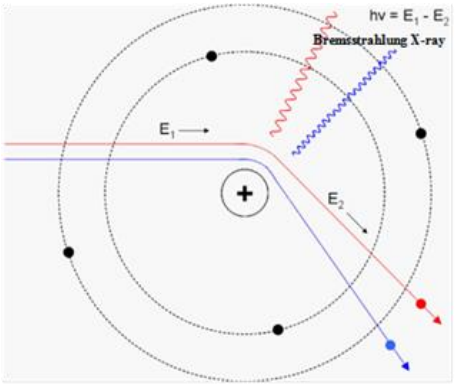

Diagram showing the generation process of X-ray (braking radiation)

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- When the electron passes close to the nucleus, it will be deviated from its original path due to Coulomb forces (Maxwell's theory)
- So, according to Maxwell's general theory of electromagnetic rays, the energy increase through a vacuum by the electromagnetic field.
- As the electron approaches the nucleus, it will be affected by the electromagnetic field emanating from the nucleus, and it will suffer a sudden negative acceleration and deviation as a result of this.
- Thus, the deviation of the electron from its path causes lose its energy in the form of Bremsstrahlung x-ray.

Two : Characteristic X-ray

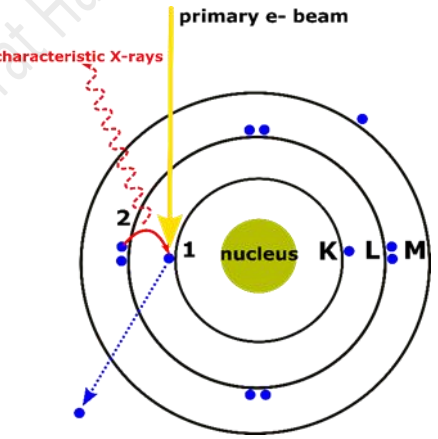

Diagram showing the generation process of X-ray (Characteristic X-ray)

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Characteristic X-rays are produced when an electron incident on the atom, as follows :

- The incident electron (which carries a kinetic energy) on the atom causes the electron to move out of the K, L, or M orbitals, leaving the atom ionized.
- This electron will carry an energy that is its binding energy in its orbit from which it exited.
- After the short lifetime of the excited electrons, they return to the lower energy state or ground state (spontaneous) by releasing energy in the form of photons.
- This photons (releasing energy) represents X-ray.

❑ X-Ray Regulations

The regulations on the handling of X rays are very similar to the regulations on standard radiation protection. The X-ray regulations in the European Union apply to those X-ray tubes and X-ray installations in which electrons are accelerated at least to 5 keV and in which they are limited to a maximum energy of 1 MeV. All installations in which electrons can be accelerated to energies beyond 1MeV are subject to the regulations of standard radiation protection.

Devices and installations that produce unwanted radiation, like old-fashioned TV screens, where electrons are accelerated up to energies of something like 20 keV, do not require a license if a dose rate of 1 μSv/h at a distance of 10 cm from the surface is not exceeded or if they are approved by the competent authority by way of a design approval.

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The X-ray regulations, of course, mainly concern X-ray tubes used for X-ray diagnosis and X-ray therapy on humans. It is desirable to obtain the best X-ray image available for a particular radiation exposure. At the same time one should try to reduce the radiation exposure by improving the X-ray detection system and image reconstruction without affecting the image quality. The radiation dose of the patient has to be documented. If the patient wants a copy for patients of the documentation about the received X-ray doses, it has to be provided to the patient.

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