Electromagnetic Application: X-RAY

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***Abstract*- The collision with a moving particle excites the atom. This causes an electron to jump to a higher energy level. The electron falls back to its original energy level, releasing the extra energy in the form of a light photon or X-ray.**

I. Introduction

X-rays (or X - radiations) are forms of electromagnetic radiations. X-rays are basically the same thing as visible light rays. Both are wavelike forms of electromagnetic energy carried by particles called photons. The difference between X-rays and visible light rays is the energy level of the individual photons. This is also expressed as the wavelength of the rays. The relation energy, E, of a photon is determined by its frequency, V, and Planck's constant, h and can be written as

$$E = h \, . \, V \qquad (1)$$

The wavelength, λ, of light is related to V from the following equation:

$$\lambda = \frac{c}{V} \qquad (2)$$

X-rays have a wavelength in the range of 10 to 0.001 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (30 × 1015 Hz to 30 × 1018 Hz) and energies in the range 120 eV to 120 keV. They are shorter in wavelength than ultraviolet rays. Our eyes are sensitive to the particular wavelength of visible light, but not to the shorter wavelength of higher energy X-ray waves or the longer wavelength of the lower energy radio waves. Fig. 1 shows the wavelength of different radiation types. In many languages, X-ray is called Röntgen radiation after one of its first investigators, Wilhelm Conrad Röntgen.

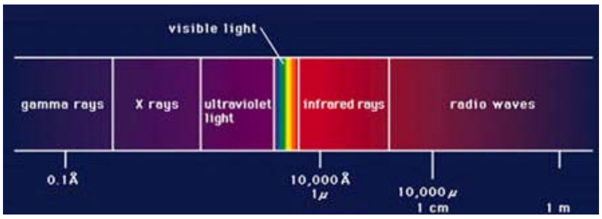

Fig.1: The wavelength of different ray types

II. History

A brief history for the development of the x-ray is presented here:

- Wilhelm Röntgen

In 1895, a German physicist named Wilhelm Roentgen made the discovery while experimenting with electron beams in a gas discharge tube. Roentgen noticed that a fluorescent screen in his lab started to glow when the electron beam was turned on. This response in itself wasn't so surprising -- fluorescent material normally glows in reaction to electromagnetic radiation -- but Roentgen's tube was surrounded by heavy black cardboard. Roentgen assumed this would have blocked most of the radiation. Roentgen placed various objects between the tube and the screen, and the screen still glowed. Finally, he put his hand in front of the tube, and saw the silhouette of his bones projected onto the fluorescent screen. Immediately after discovering X-rays themselves, he had discovered their most beneficial application.

- Johann Hittorf

German physicist Johann Hittorf (1824 – 1914), a coinventor and early researcher of the Crookes tube, found when he placed unexposed photographic plates near the tube, that some of them were flawed by shadows, though he did not investigate this effect.

- Ivan Pulyui

In 1886, a lecturer in experimental physics at the University of Vienna, he found that sealed photographic plates became dark when exposed to the emanations from the tubes. Early in 1896, just a few weeks after Röntgen published his first X-ray photograph, Pulyui published high-quality x-ray images in journals in Paris and London.

- Nikola Tesla

In April 1887, Nikola Tesla began to investigate X-rays using high voltages and tubes of his own design, as well as Crookes tubes. From his technical publications, it is indicated that he invented and developed a special single-electrode X-ray tube, which differed from other X-ray tubes in having no target electrode. The principle behind Tesla's device is called the Bremsstrahlung process, in which a high-energy secondary X-ray emission is produced when charged particles (such as electrons) pass through matter.

- Thomas Edison

In 1895, Thomas Edison investigated materials' ability to fluoresce when exposed to X-rays, and found that calcium tungstate was the most effective substance. Around March 1896, the fluoroscope he developed became the standard for medical X-ray examinations.

III. How do X-ray work

Most people are familiar with the concept of X-rays. In fact, many people have experienced having X-rays taken, either at the request of a doctor, or a dentist. However, not everyone understands the process that allows X-rays to work. Here is some background on X-rays, and how they are used in a number of situations. The discovery of a method to produce X-rays is usually attributed to Wilhelm Conrad Röntgen, a physicist at the University of Wurzburg during the latter 19th century. On 8 November 1895, Röntgen first developed the process that came to be known as Rongten rays and later X-rays. The original designation of Röntgen ray tended to be used by the scientific community. In most of Röntgen's surviving notes and speeches, he usually refers to the phenomenon as X-rays. Röntgen's work provided him with the distinction of being the first recipient of the Nobel Prize for Physics in 1901.

X-rays are designed to be able to penetrate through non-metallic materials. Because of this property, it is possible to use X-ray equipment to create an image of the human body that allows the attending physician to get a look at what is happening inside, without the need for an invasive procedure. The procedure involves creating a concentrated beam of electrons and smashing them into some sort of metal film. The result of that crash between the metallic film and the highly charged electrons is a concentration of high-energy electromagnetic radiation. This radiation is what is normally termed X-rays.

Along with the sheet of metallic film, a second sheet serves as a filter that prevents the beam from scattering or making the image produced by the action foggy or otherwise difficult to view. As the image appears, the portions of the body that contain metals, such as calcium enriched bones will appear outlined. Other mineral deposits help to identify the presence of growths such as tumors, and also identify breaks in the bones or foreign objects in the body such as knife blades or bullets. In some instances, the patient may ingest what is known as a contrast agent, such as barium or iodine. This helps to make the presence of veins and arteries and organs appear more prominently on the X-ray.

X-ray technology is not without some degree of risks. High levels of exposure to radiation in a short period of time can produce a variety of health problems. Still, the occasional exposure to X-rays during an annual checkup or at the dentists office are not likely to result in any type of permanent damage.

X-rays are not just used for imaging the human body for medical purposes. The same basic process is used to scan baggage at many airports, check suspicious packages at a post office or courier depot, and to scan the interior of walls to check for electrical lines and pipes before demolition of the wall.

IV. Uses

X-ray technology has been in the world of medicine, but X-rays have played a crucial role in a number of other areas as well. Here are some of its uses:

Examination of Baggage in Airports: The use of X-rays in airports to examine for the presence of dangerous weapons or bombs is a routine practice. The cargo is also examined similarly for illegal transit of goods.

Industrial Use: X-rays reveal structural information about the material through which it passes or falls over. It can therefore be used to detect structural deficits or cracks in metal objects that are likely to be missed by the human eye. It is also used to reveal stress related changes in building materials for bridges and aircrafts.

Medical Use: X-rays are widely used in medicine to reveal the architecture of the bone and other soft tissues and to find out any abnormality in the form of fracture, growth of tumor etc. It is also used in dental imaging.

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