Radiation

Physics of diagnostic x-rays :

This subject discusses the physical principles involved in the diagnostic use of x-rays in medicine .

The x-ray photon is a member of the electromagnetic family that includes light of all types (infrared, visible and ultraviolet ,radiowaves, radar and television signals and gamma rays .

Like many important scientific breakthroughs, the discovery of x-rays was accidental, in the fall of 1895. , W.C. Roentgen, a physicist at the university of Wurzburg in Germany , was studying ***cathode rays*** in his laboratory, he was using a fairly high voltage across a tube covered with black paper that had been evacuated to a low pressure .

When he "excited" the tube with high voltage , he noticed that some crystals on a nearby bench glowed and that the rays causing this fluorescence could pass through solid matter, within a few days Roentgen took the first x-ray film .

The main components of modern x-ray unit are :

1. A source of electrons – a filament or cathode .
2. An evacuated space in which to speed up the electrons .
3. A high positive potential to accelerate the negative electrons .
4. A target or anode, which the electrons strike to produce x-rays .

The unit used for radiation exposure is the Roentgen (R), a measure of the a mount of electric change produced by ionization in air :

$$1R=2.58*10^{-4} \text{ C/Kg of air .}$$

x-ray slices of the body :

The radiologist often takes x-ray images from different directions, such as from the back, the side and an intermediate (oblique) angle .

taking x-ray images of slices of the body or body section radiography, better known as tomography, was first proposed in about 1930 as a better way to distinguish these shadows, both conventional tomography and computerized tomography .

axial tomography was dramatically improved in 1972 when Hounsfield developed computerized axial tomography (CAT), sometimes called computerized tomography (CT),for EMI Limited in England . Hounsfield made use of a technique for analyzing data by computer that was originally developed for use in astronomy .

physics of nuclear medicine (radioisotopes in medicine)

investigator of radioactivity discovered that certain natural elements primarily the very heavy ones, have unstable nuclei that disintegrate to emit various rays –alpha (α), beta (β) and gamma (γ) rays .

the alpha, beta and gamma rays were found to have quite different characteristics, alpha and beta particle bend in opposite directions in magnetic and electrical fields, alpha particles are positively charged and beta particles are negatively charged .

Alpha particles which stop in a few centimeters of air are the nuclei of helium atoms, ***beta rays*** are more penetrating but can be stopped in a few maters of air or a few millimeters of tissues, they are high speed electrons, ***gamma rays*** are very penetrating and are physically identical to x-rays, the usually have much higher energies than the x-rays used in diagnostic radiology .

Alpha and gamma rays from a given source have fixed energies but beta rays have a spread of energies up to a maximum characteristic of the source .

Each element has a specific number of protons in the nucleus. For example carbon has six protons, nitrogen has seven protons and oxygen has eight protons .

However, for each element, the number of neutrons in the nucleus can vary, nuclei of a given element with different numbers of neutrons are called ***isotopes*** of the element .

If they are not radioactive they are called ***stable isotopes*** and if they are radioactive they are called ***radioisotopes***, for example carbon has two stable isotopes (^{12}C and ^{13}C) and several radioisotopes (e.g, ^{11}C ,^{14}C,and ^{15}C) .

Most elements do not have naturally occurring radioisotopes, but radioisotopes of all elements can now be produced artificially, isotope mean "in the same place" and should be used when referring to a single element, the word ***radionuclides***is appropriate when several radioactive elements are involved .

There are over 1000 known radionuclides, most man-made. Heavy elements tend to have many more radioisotopes than light elements; for example, iodine has 15 known radioisotopes, while hydrogen has 1, tritium (^{3}H) . A particular radionuclide can be identified by its radioactivity alone just as human can be identified by their fingerprints.

Characteristics that help identify the radionuclide are the type and energy of its emitted particles or rays .

The most common emissions from radioactive elements are beta particles and gamma rays . since beta particles are not very penetrating, they are easily absorbed in the body and are generally of little use for diagnosis. However, some beta-emitting radionuclides such as (^{3}H and ^{14}C) play an important role in medical research .(^{23}P) is used for diagnosis of tumors in the eye because some of its beta particles have enough energy to emerge from the eye .most clinical diagnostic procedures use photon of some type- usually gamma rays with energies above 100kev can penetrate many centimeters of tissue, and a gamma emitter in the body can be located and mapped by a detector outside the body. All of the gamma-emitting radionuclides of common organic elements carbon, nitrogen, and oxygen-are short lived, which makes their use in clinical medicine difficult without an accelerator . few medical centers have installed cyclotrons for producing short-lived radionuclides.

A metastable radionuclide decays by emitting gamma rays only and daughter nucleus differs from its parent only in having less energy .

Each radionuclide decays as affixed rate commonly indicated by the half-life ($T_{1/2}$), the time needed for half of radioactive nuclei to decay .

The basic equation describing radioactive decay is

$$A = A_{\circ} e^{-\lambda t}$$

Where A is the activity in disintegrations per second, $A_{\circ}$ is the initial activity , λ is decay constant, and t is the time since the activity was $A_{\circ}$. If t measured in hours, λ must be in hours^{-1} . if λ is small, that is, less than 0.1 , it is very nearly the friction of the radionuclide that decays per unit time . for ^{198}Au, λ is 0.01 hr^{-1}, which means that 0.01(or 1%) decays per hours :

$$A = \lambda N$$

Where N is the number of radioactive atoms . equation can be used to determine that half-life of long-lived radionuclide the decay constant is related to the half-life by the simple equation

$$T_{1/2} = \frac{0.693}{\lambda}$$

The constant 0.693 is the natural logarithm of 2 . the relationship between the decay constant and the half-life is illustrated .