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Medical applications of Gamma Radiations

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Abstract

Gamma-rays originate from the decay of excited states of the atomic nuclei in a similar manner as the visible light originates from the decay of the atom itself. Gamma rays belong to the class of ionizing radiation, together with alpha rays (doubly ionized atoms of helium) and beta rays (electrons). The spectroscopy of gamma rays, having the unique feature that by photoeffect transform their total energy to the energy of electrons in the detection material, contributed decisively to the establishing of the decay schemes of atomic nuclei. Strong sources of gamma radiation are widely used in contemporary technologies for cancer treatment, material modification, medical imaging, and food sterilization. The main goal of this research paper is to present to the non-specialist reader the contemporary applications of gamma rays by selected chapters on that issue.

Keywords: Medical applications, Gamma Radiations, Atomic Nuclei

Introduction

Medical images may be formed and constructed by several medical imaging modalities. Each imaging modality provides unique image features. For instance, X-ray planar imaging provides higher spatial resolution than computed tomography (CT) imaging. However, CT images provide a better low contrast resolution (Bushberg et al., 2002). In addition, X-ray image acquisition is fast, easy to use, and may be portable, whereas, CT provides tomography images which allow for the construction of 3D data (Alyassin, 2009, Fournier et al., 2007).

Unlike CT, the magnetic resonance imaging (MRI) modality uses non-ionizing radiation to form medical images that provide an excellent soft tissue contrast (Hendee and Ritenour, 2002). However, MRI requires longer acquisition time, is more expensive, has lower bone and calcification visualizations, and is less quantitative than CT (Alyassin, 2009). All these modalities complement each other. Currently there is a revolution in multimodality medical data such as positron-emission-tomography PET and CT, single photon emission computed tomography (SPECT) and CT, X-ray and Ultrasound (US), PET and MRI. Multimodality-data has proven to provide better diagnostic information than an individual medical modality (Kapur et al., 2002, Krug et al., 2010, Liu et al., 2011, Pichler et al., 2008).

In ionizing radiation imaging modalities images may be acquired through transmission or emission scans. X-ray and CT provide transmission scans which mean the X-ray source is located outside the patient and the X-ray field transmitted through the patient records the final image on the image receptor. Unlike CT and X-ray, nuclear medicine (NM) images are formed through an emission scan which means the source of radiation is located inside the patient and the radiation emitted from the source is recorded on the detectors that are located outside the patient. NM imaging mainly provides functional information whereas the transmission scans mainly provide the anatomical information (Raan et al., 2000). The sources of radiation that are used in diagnostic NM imaging are radioactive sources that mainly emit gamma-rays with energies in the diagnostic range (Huda and Slone, 2003, Bushberg et al., 2002).

Radioactive sources have been reported in literature to provide transmission scans to show some anatomical structures. However these scans have either been used for special procedures or with special dedicated detectors. They have not addressed the requirements or the needs of general diagnostic medical imaging procedures with gamma-rays. For instance, some researchers have used gamma-ray scans for attenuation correction in PET (Bailey et al., 2005, Kaplan and Hynor, 1999, Raan et al., 2000). Other researchers have generated beta particle images and gamma-ray images with a special digital probe that was used in radioguided surgery (Tipnis et al., 2004). Some researchers have developed a special radiation-imaging device for imaging with low-intensity gamma-ray sources (Woodring et al., 1999) while others have used gamma-ray imaging with a multiple pinhole imager in NM (Meng et al., 2003).

In addition, much work has been published about industrial gamma-ray radiography

(Verbinski and Orphan, 1997). However, the radioactive sources that are typically used in industrial gamma-ray radiography are Cs-137 and Co-60, which emit on the average, high energy photons of 0.662 MeV and 1.25 MeV, respectively (IAEA, 1999). These energies are much higher than the diagnostic energy range. Amercium-241 (Am-241) emits gamma-rays within diagnostic X-ray range (25–150 keV) and has been used in brachytherapy (Muench and Ravinder, 1992, Randinder et al., 1990, Ravinder et al., 1987). It was briefly introduced in producing medical images (AbdulMajid, et al., 2010). Therefore, there is a tremendous lack of testing the feasibility of using the Am-241 radioactive source in producing gamma-ray transmission scans that provide medically diagnostic information.
Gamma radiation is high energy radiation. It is known as electronic magnetic radiation that carries a lot of energy. It is highly penetrating that is emitted by certain radionuclides nucleus followed by radioactive decay.
Gamma rays are discovered by Henri Becquerel, a French physicist, and the term was coined by Ernest Rutherford.

Mechanism of production of Gamma Radiation

Gamma rays produce in the decay of the radioactive nucleus of atoms and the decomposition of subatomic particles. These radiations generate by energetic and hottest objects like stars, neutrons, regions circa, pulsar, supernova explosions, and black holes.
The gamma rays on earth are produced by emissions caused due to lightning, nuclear explosion, and radioactive decay. Nuclear reactions like fission, fusion, gamma decay and alpha decay also emit gamma rays. The frequency of gamma radiation ranges from 3X 10 18 Hz to 5X10 22 Hz.

Unit of Gamma Radiation

We estimate it in API units. The full form of API is American Petroleum Institute. This unit measures natural gamma-rays in the ground.

Mechanism of Isolating Gamma Rays for Detection

Unlike X-rays, we cannot see gamma rays using mirrors. Gamma rays have a very short wavelength which enables them to pass through any space and nothing can detect them.
For detecting Gamma Rays, densely packed crystal block channels are used. Thus, as the rays pass through the compact atoms of the crystals, the crystal electrons constantly collide with the rays. This gives rise to an automatic chain of events where the rays begin to lose energy and thus creates small charges that the sensors pick up and place within the crystals.
Further, we refer to this mechanism of detection of Gamma Rays as Crompton Scattering.

Gamma Radiation Wavelength

This electromagnetic radiation is of high energy with energy greater than 100 KeV or Kilo ElectronVolt. The frequency is greater than 1019 Hz. It comes with the smallest wavelength of fewer than 10 picometers.

Medical importance of Gamma Radiation

Importance in Clinical Medicine

The fact that gamma rays kill any living organism is an advantage to the medical field, especially the field of oncology. High doses of gamma rays can kill cancerous cells in a process called radiation therapy (lower doses could lead to cells becoming cancerous). The process of radiation therapy kills the DNA of cancerous cells, preventing growth or division with the use of a machine called an accelerator or radioactive sources placed inside the patient. The main focus of the radiation oncologist is to target the dose of radiation to the cancer as much as possible to avoid side effects. Side effects depend on the area of treatment.
Gamma rays are also used for sterilization of medical equipment. Gamma rays easily pass through the packaging of medical equipment (can only be stopped by thick lead) and kill living tissue such as viruses and bacteria.

Uses in Medicine

Gamma rays are a form of **electromagnetic radiation** and are used in medicine to treat cancer. These rays have the ability to penetrate deep into the human body, which makes them great for targeting specific tumours.
Gamma rays are also used in medical imaging, such as Computed Tomography (CT). This is a process that is performed by doctors to get an accurate view of a patient's brain or another

part of the body. Doctors use CT scans to diagnose many diseases and conditions. Gamma rays are a form of radiation that can be emitted by radioactive substances such as uranium, plutonium and cobalt. They can also be produced artificially from radioactive isotopes.

Gamma rays are widely used in medicine and specifically in the area of oncology to treat malignant and cancerous tumors during a process called gamma knife surgery. In this type of treatment, concentrated beams of gamma rays are directed at tumors in order to kill cancerous cells. These high energy rays ionize water in the cancerous cell, producing H and OH free radicals. The free radicals are highly reactive and therefore interact and damage chromosomes in the cell. Some of the radiation directed at the tumor interacts and directly damages chromosomes without the use of free radicals.

Gamma Rays Used for Cancer Treatment

The process named Gamma Knife Surgery is used to treat cancer. High beams of concentrated gamma rays are directed towards the tumour cells. When gamma rays are used in high doses, they can kill the cancer or tumour cells. They first spot the tumour cells and slow them down, ultimately killing them by damaging their DNA. The dead cells are then removed by the body.

Gamma Rays Uses in Everyday Life

Gamma rays are an important part of modern life. They are used to provide a safe environment for people and the environment.

Gamma rays have many uses in everyday life. We use them to find out if food is safe, scan our bodies, see what is happening inside volcanoes, and they are even used to find out if there are any cracks in buildings and bridges. Gamma rays are the most powerful form of electromagnetic radiation. They are emitted from radioactive materials and nuclear reactions. Gamma rays are used in everyday life for medical imaging, sterilisation, and food processing.

Uses of Gamma Rays

Gamma rays are used in a variety of fields, but they are most commonly used in the medical field. They are used to diagnose and treat cancer patients.

These rays are produced by radioactive nuclei and can be used to treat cancer. They can also be used in the production of food and other products like silicon chips, plastics, and paints.

Gamma Rays are high-energy, short-wavelength electromagnetic radiation. They can be used to treat cancer and other diseases by killing the cells that need to be eliminated.

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