PHYSICS OF REMOTE GAMMA THERAPY

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Abstract
The work presents the physical concept of gamma radiation. The main processes that occur when gamma radiation passes through matter. It shows the advantage of gamma therapy and ways to obtain gamma radiation, as well as the half-life of the isotope, which is the source of gamma radiation.

Keywords: Gamma therapy, source, radiation, curie, radioactivity, isotope, x-ray, photon, absorption, dose.

Introduction

Gamma therapy or Curie therapy is a complex of methods for conducting radiation therapy (mainly for cancer patients) using gamma radiation from radioactive isotopes and other radioactive materials . The effect of gamma radiation on the patient's body is directly proportional to the amount of radiation dose absorbed by the patient.

Gamma radiation **is** a type of electromagnetic radiation characterized by an extremely short wavelength - less than $2 \cdot 10^{-10}$ m - and, as a result, pronounced corpuscular and weakly expressed wave properties.

Refers to ionizing radiation , that is, to radiation whose interaction with matter can lead to the formation of ions of different signs.

Gamma radiation is a stream of photons (gamma quanta) with high energy. It is conventionally considered that the energies of gamma radiation quanta exceed 10^{5} eV , although the sharp boundary between gamma and X-ray radiation is not defined [1].

On the electromagnetic wave scale, gamma radiation borders on X-rays, occupying a range of higher frequencies and energies.

In the range of 1-100 keV, gamma radiation and X-rays differ only in the source: if a quantum is emitted in a nuclear transition, then it is usually classified as gamma radiation; if during interactions of electrons or during transitions in the atomic electron shell, then it is classified as X-ray radiation.

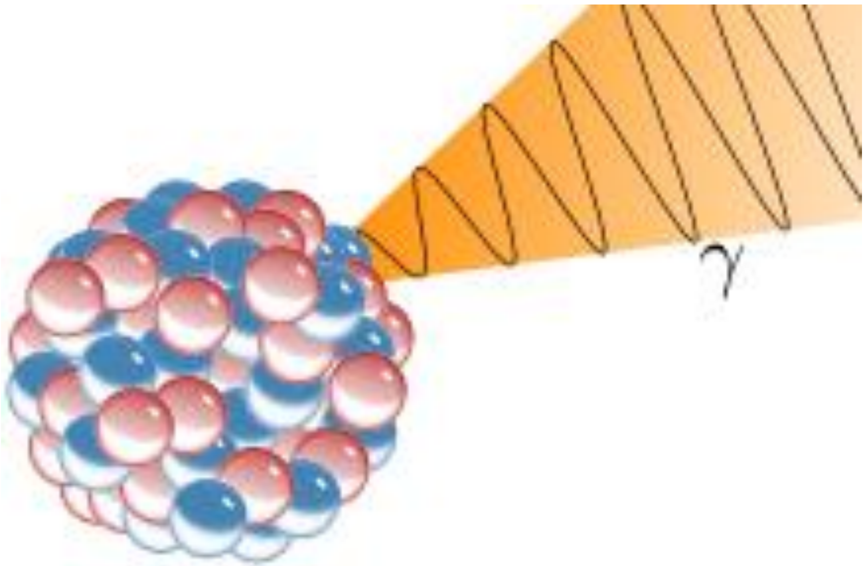
From the point of view of physics, quanta of electromagnetic radiation with the same energy do not differ, so this division is arbitrary.

Gamma radiation is emitted during transitions between excited states of atomic nuclei , during nuclear reactions , during interactions and decays of elementary particles, and also during the deflection of energetic charged particles in magnetic and electric fields.

The energy of gamma quanta arising during transitions between excited states of nuclei does not exceed several tens of MeV. The energies of gamma quanta observed in cosmic rays can exceed hundreds of GeV.

Gamma radiation was discovered by the French physicist Paul Villard in 1900 while studying radiation from radium . The three components of ionizing radiation from radium-226 (mixed with its daughter radionuclides) were separated by the direction in which they deflected in a magnetic field: radiation with a positive electric charge was called α -rays , with a negative charge - β -rays , and electrically neutral radiation, not deflected in a magnetic field, was called γ -rays.

This terminology was first used by E. Rutherford in early 1903. In 1912, Rutherford proved the electromagnetic nature of gamma radiation.



Gamma rays, unlike α-rays and β-rays , do not contain charged particles and therefore are not deflected by electric and magnetic fields and are characterized by greater penetrating power at equal energies and other equal conditions.

Gamma quanta cause ionization of atoms of matter. The main processes that occur when gamma radiation passes through matter:

- Photoelectric effect - the energy of a gamma quantum is absorbed by an electron of the atom's shell, and the electron, performing work function , leaves the atom (which becomes positively ionized).
- Compton effect - a gamma quantum is scattered when interacting with an electron, and a new gamma quantum of lower energy is formed, which is also accompanied by the release of an electron and ionization of the atom.
- The effect of pair formation - a gamma quantum in the electric field of the nucleus is converted into an electron and a positron.
- Nuclear photoelectric effect - at energies greater than several tens of MeV, a gamma quantum is capable of knocking nucleons out of the nucleus.

Gamma irradiation, depending on the dose and duration, can cause chronic and acute radiation sickness .

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Stochastic effects of radiation include various types of cancer [2-14].
At the same time, gamma irradiation suppresses the growth of cancer and other rapidly dividing cells when applied locally. Gamma radiation has a mutagenic and teratogenic effect.
Gamma therapy is one of the newest methods among all distance methods.
Its advantages:
1) Gamma radiation has high energy, due to which the rays are able to penetrate deeper. Due to this, it becomes possible to treat tumors in hard-to-reach places.
2) According to statistics, remission occurs in 66% of people.
3) Despite the deep penetrating ability, tissue surfaces are damaged little.
Gamma rays are obtained in the following ways:
1) Decrease in frequency due to scattering of electromagnetic a filament wave on a free electron.
2) When the photoelectric process occurs, the photon transfers all its energy to the electron, which is knocked out as a result is formed from an atom.
3) In the electric field of the nucleus, the gamma quantum turns into an electron and a positron.
4) Formation of the lowest molecular level of the genetic code.
5) In order to extract an electron from any shell , the rays change the direction of propagation without changing the quantum energy, and therefore the wavelength of the radiation.
Gamma therapy uses gamma units. Often the radiation sources are ^{137}Cs, ^{60}Co, ^{226}Ra (cesium, radium, cobalt respectively). An example of gamma decay of cobalt .

$$ {}^{60}_{27}Co \rightarrow {}^{60}_{28}Ni + {}^{0}_{-1}e \rightarrow {}^{60}_{28}Ni + \gamma\text{-photon} $$

The energy of these elements is approximately 4.8 MeV . This is why gamma rays can penetrate deep into tissue. Devices for this therapy can deliver targeted, area-controlled gamma radiation.
It is equipped with a protective container made of lead, tungsten, or uranium, which has a radiation source. Treatment occurs by destroying the most radiation-sensitive tumor cells and disrupting the reproduction of weakly sensitive cells.
As a result, the tumor is divided, which stops its blood supply. At the same time, neighboring cells remain unharmed, since the therapy is localized .
When performing gamma therapy, each specialist must know the half-life of the isotope that is the source of gamma radiation, because the radiation dose is determined by two factors:
1) Features of the physiology of the human body.
2) Half-life of the isotope.
In addition to the advantages, this method of external beam radiation therapy has disadvantages:
1) If the radiation dose is set incorrectly, you can get radiation sickness.
2) Depending on the physiology of the human body, the recovery process after treatment can be quite long.
Gamma rays can be harmful to humans, so the following points should be taken into account:

1) Increase the distance to the radiation source.
2) The materials from which the walls of gamma installations are made must be dense (lead, concrete, etc.).
3) The radiation dose must be carefully controlled.

Thus, localized treatment of tumor tissue is one of the main advantages, and despite the disadvantages associated with ionizing radiation, a sufficiently large number of positive results indicate the need for further development of this method.

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