Beta particle

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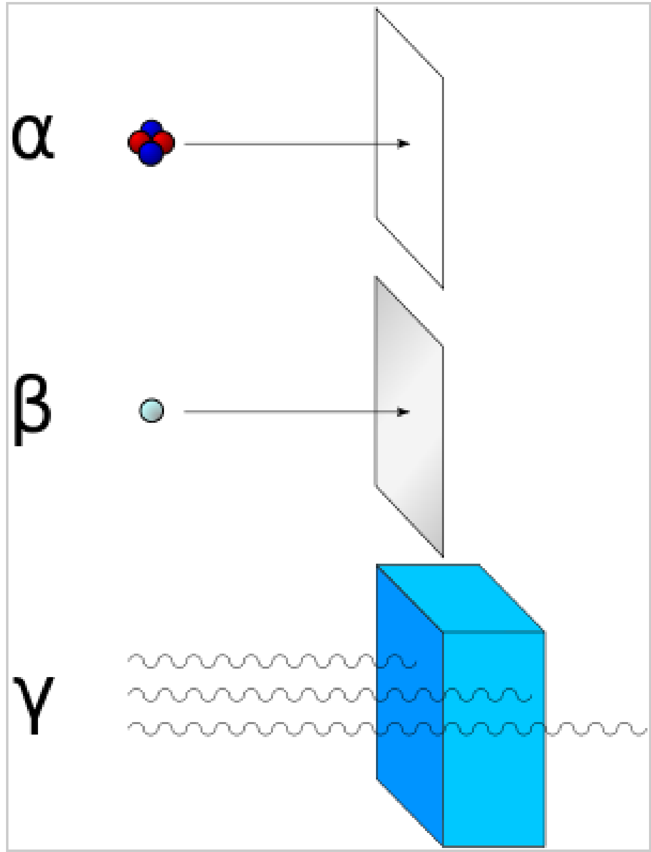
Beta particles are high-energy, high-speed electrons or positrons emitted by certain types of radioactive nuclei such as potassium-40. The beta particles emitted are a form of ionizing radiation also known as beta rays. The production of beta particles is termed beta decay. They are designated by the Greek letter beta (β). There are two forms of beta decay, β^- and β^+, which respectively give rise to the electron and the positron.[1]



Alpha radiation consists of helium nuclei and is readily stopped by a sheet of paper. Beta radiation, consisting of electrons or positrons, is halted by an aluminum plate. Gamma radiation is dampened by lead.

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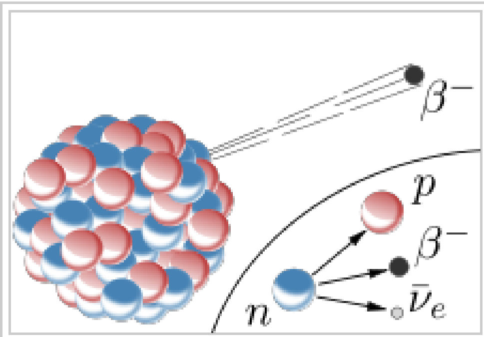
β^- decay (electron emission)



Beta decay

An unstable atomic nucleus with an excess of neutrons may undergo β^- decay, where a neutron is converted into a proton, an electron and an electron-type antineutrino (the antiparticle of the neutrino):

$$n \rightarrow p + e^- + \bar{\nu}_e$$

This process is mediated by the weak interaction. The neutron turns into a proton through the emission of a virtual W^- boson. At the quark level, W^- emission turns a down-type quark into an up-type quark, turning a neutron (one up quark and two down quarks) into a proton (two up quarks and one down quark). The virtual W^- boson then decays into an electron and an antineutrino.

Beta decay commonly occurs among the neutron-rich fission byproducts produced in nuclear reactors. Free neutrons also decay via this process. This is the source of the copious amount of electron antineutrinos produced by fission reactors.

β^+ decay (positron emission)

Unstable atomic nuclei with an excess of protons may undergo β^+ decay, also called positron decay, where a proton is converted into a neutron, a positron and an electron-type neutrino:

$$p \rightarrow n + e^+ + \nu_e$$

Beta plus decay can only happen inside nuclei when the absolute value of the binding energy of the daughter nucleus is higher than that of the mother nucleus.

Interaction with other matter

Of the three common types of radiation given off by radioactive materials, alpha, beta and gamma, beta has the medium penetrating power and the medium ionising power. Although the beta particles given off by different radioactive materials vary in energy, most beta particles can be stopped by a few millimeters of aluminium. Being composed of charged particles, beta radiation is more strongly ionising than gamma radiation. When passing through matter, a beta particle is decelerated by electromagnetic interactions and may give off bremsstrahlung x-rays.

Uses

Beta particles can be used to treat health conditions such as eye and bone cancer and are also used as tracers. Strontium-90 is the material most commonly used to produce beta particles.

Beta particles are also used in quality control to test the thickness of an item, such as paper, coming through a system of rollers. Some of the beta radiation is absorbed while passing through the product. If the product is made too thick or thin, a correspondingly different amount of radiation will be absorbed. A computer program monitoring the quality of the manufactured paper will then move the rollers to change the thickness of the final product.

An illumination device called a 'betalight' contains tritium and a phosphor. As tritium decays, it emits beta particles; these strike the phosphor, causing the phosphor to give off photons, much like the cathode ray tube in a television. The illumination requires no external power, and will continue as long as the tritium exists (and the phosphors do not themselves chemically change); the amount of light produced will drop to half its original value in 12.32 years, the half-life of tritium.

Beta plus (or positron) decay of a radioactive tracer isotope is the source of the positrons used in positron emission tomography (PET scan).

History

Henri Becquerel, while experimenting with fluorescence, accidentally found out that uranium exposed a photographic plate, wrapped with black paper, with some unknown radiation that could not be turned off like X-rays. Ernest Rutherford continued these experiments and discovered two different kinds of radiation:

- alpha particles that did not show up on the Becquerel plates because they were easily absorbed by the black wrapping paper

- beta particles which are 100 times more penetrating than alpha particles.

He published his results in 1899.[2]

Health

Beta particles are able to penetrate living matter to a certain extent and can change the structure of struck molecules. In most cases such change can be considered as damage with results possibly as severe as cancer and death. If the struck molecule is DNA it can show a spontaneous mutation.

Beta sources can be used in radiation therapy to kill cancer cells.

See also

- Electron
- Electron irradiation
- Particle physics
- α (alpha) particles
- Rays:
  - γ (gamma) rays
  - n (neutron) rays
  - δ (delta) rays
  - ε (epsilon) rays

References

1. ^ "Beta Decay" (http://www.lbl.gov/abc/wallchart/chapters/03/2.html) . http://www.lbl.gov/abc/wallchart/chapters/03/2.html.
2. ^ E. Rutherford (1899). "Uranium radiation and the electrical conduction produced by it" (http://books.google.com/books?id=ipMOAAAAIAAJ&pg=PA109) . *Philosophical Magazine* **47** (284): 109–163. http://books.google.com/books?id=ipMOAAAAIAAJ&pg=PA109.

Further reading

- http://www.oasisllc.com/abgx/radioactivity.htm
- http://galileo.phys.virginia.edu/classes/252/rays_and_particles.html
- http://www.physics.isu.edu/radinf/hist.htm
- http://www.nextenergynews.com/news1/next-energy-news-betavoltaic-10.1.html
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