About Beta Decay

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Abstract

Contemporary physics states that an electron neutrino takes part in all events of beta decay. Here we show that electron-positron pairs participate in all beta decay events. For this reason, the hypothesis of electron neutrino presence is not necessary in β^-, β^+ and electron capture reactions.

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Introduction

Since Henri Becquerel in 1900 showed that beta particles are electrons [1], several problems arise. The main ones are:

1. The distribution of beta particle energies was in apparent contradiction to the law of conservation of energy.

2. The change of nuclear spin must be an integer, but the electron spin is 1/2, therefore angular momentum would not be conserved if beta decay were simply electron emission.

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3. The emission of a single electron violates the lepton number conservation law.

It was therefore assumed that there was a small neutral particle called a neutrino. The neutrino should be a lepton with a half integer spin and it carries away excess energy. The neutrino interaction with matter should be so weak that detecting it proves a severe experimental challenge. Direct observation of the neutrino is impossible. So indirect methods should be used. The existence of the neutrino was obtained by observing the recoil of nuclei or by positron appearance in the process of proton conversion to neutron.

There are several types of beta decay:

1. Beta minus decay (β^-). In this case the nucleus emits an electron. The neutron converts to the proton inside the nucleus. A special variant of this mode is the decay of the free neutron.

2. Beta plus decay (β^+). In this case the nucleus emits a positron. The proton converts to the neutron inside the nucleus.

3. Beta capture. In this case the nucleus captures an electron from the lower energy level in the atom. The proton converts to the neutron inside the nucleus.

A detailed analysis shows that for neutron decay [2] the neutrino hypothesis is not necessary. A detailed analysis of all variants of beta decay follows.

β^- decay

The β^- decay is possible in neutron rich nucleons if the energy difference between the initial and final states exceeds $2m_ec^2$, where m_e is the mass of electron and c is the speed of light. If the energy difference is insufficient for creating an electron-positron pair the decay is impossible. The decay of carbon-14 into nitrogen-14 with the emission of an electron is a typical nuclear reaction. Inside the nucleus of carbon-14, a neutron converts to the proton according to the reaction:

$$n \rightarrow n + e^+ + e^- \rightarrow (n + e^+) + e^- \rightarrow p^+ + e^- . \qquad (1)$$

An electron-positron pair is generated inside the nucleus. The positron converts the neutron to the proton and the electron is emitted away.

Accordingly the complete process of carbon-14 decay is as follows:

$$^{14}{}_{6}C \rightarrow (^{14}{}_{6}C + e^+ + e^-) \rightarrow (^{14}{}_{6}C + e^+) + e^- \rightarrow {}^{14}{}_{7}N + e^- .$$

β^+ decay

The β^+ decay is possible in proton rich nucleons if the energy difference between the initial and final states exceeds $2m_ec^2$, where m_e is the mass of an electron and c is the speed of light. If the energy difference is insufficient for creating an electron-positron pair the β^+ decay is impossible. The decay of magnesium-23 into sodium-23 with the emission of a positron is a typical nuclear reaction. Inside the nucleus of magnesium-23, a proton converts to the neutron according to the reaction:

$$p^+ \rightarrow p^+ + (e^- + e^+) \rightarrow (p^+ + e^-) + e^+ \rightarrow n + e^+ . \qquad (2)$$

Free energy converts to an electron-positron pair inside the nucleon. The electron is captured by a proton. As a result, the proton converts to the neutron and the positron is emitted.

Therefore the complete process of magnesium-23 decay is as follows:

$${}^{23}_{12}Mg \rightarrow ({}^{23}_{12}Mg + e^+ + e^-) \rightarrow ({}^{23}_{12}Mg + e^-) + e^+ \rightarrow {}^{23}_{11}Na + e^+.$$

β capture

The β capture is the sole decay mode in proton rich nucleons if the energy difference between the initial and final states is insufficient for creating an electron-positron pair. The decay of krypton-81 into bromine-81 with the capture of an electron is a typical nuclear reaction. Inside the nucleus of krypton-81, a proton converts to the neutron according to the reaction: $e^- + p^+ \rightarrow n + (e^- + e^+) \rightarrow n + \gamma$. (3)

The electron is captured by the proton and annihilates with the positron inside the nucleus. As a result, the proton converts to the neutron and emits a photon.

Therefore the complete process of the krypton-81 decay is as follows:

$${}^{81}_{36}Kr + e^- \rightarrow {}^{81}_{35}Br + (e^+ + e^-) \rightarrow {}^{81}_{35}Br + \gamma.$$

Conclusions

In all the beta decay processes (1, 2 and 3):

1. Energy is conserved. Practically all the decay energy is consumed for electron-positron pair creation.

2. The angular momentum is conserved. The total angular momentum is equal to the angular momentum of neutron, because the angular momentum of electron-positron pair is zero.

3. The lepton number is conserved. Within all stages of decay the lepton number is zero, because the positron and accordingly the proton have the lepton number L = -1, but for the electron L = +1.

The hypothesis of electron neutrino for β decay is not necessary.

References

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