FYS3500 - Problem set 8

Spring term 2019

Problem 1 – in class

a) Figure 1 shows the electron spectra meassured on β-particles from decay of ^{210}Bi. What does this spectra tell about the nature of β-decay? How and what can we learn about the existence of neutrinos from this spectrum?

b) Comment on the three decays in Figure 2. What can you say about the half-life of the three different decays?

c) In what nuclei do we find double beta decay (what would be prominent examples)? Argue eg. with the Feynman diagrams. Draw the Feynman diagram for double beta decay in the standard picture.
There are many experiments that look for physics beyond the standard model. If neutrinos were their own anti-particles (so called Majorana particles). How would the Feynman diagram for this process look like?

d) Show in a (semi-)classical calculation that the angular momentum transfer l (in units of $\hbar$) to a electron in β-decay is much smaller then 1. Assume a typical Q-value of 3 MeV and R= 6 fm for the nuclear radius. What do we learn about possible and forbidden β-decays?

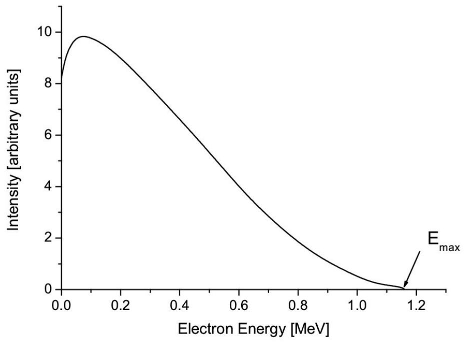

Figure 1: Electron spectra from β-decay of ^{210}Bi.

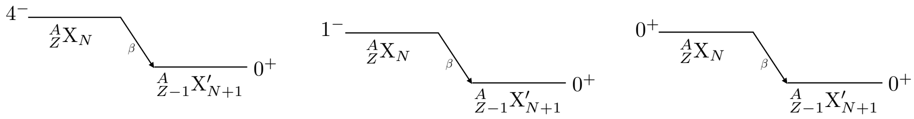

Figure 2: β-decays

Problem 2 β-delayed neutron emission

After β-decay of a excited state it is not only possible to emit γ-rays. Depending on the excitation energy of the daughter nucleus it can also emit particles. The β-delayed neutron emission is essential for the control of nuclear reactors. However, in this example we analyze the β-delayed neutron emission of ^{17}O, which leads to the gs. of ^{16}O. Here ^{17}O has before been populated by β^--decay of ^{17}N. The decay scheme is given in Figure 3

As given in the figure three neutrons are emitted with energies 383, 1171 and 1700 keV, which populate the ground state of ^{16}O.

a) Calculate the Q-value for the β-decay of ^{17}N.

b) Derive a formula that allows you to calculate the excitation energy of ^{17}O as a function of the kinetic energy of the neutron and exicitation energy of ^{16}O. Calculate the excitation energy of ^{17}O.
Hint: You get the correct formula if you take into account energy *and* momentum conservation. You may regard only the ^{17}O-^{16}O system and neglect ^{17}N.

c) Why can the β-delayed neutron emission not populate the first excited state of ^{16}O at 6.05 MeV?

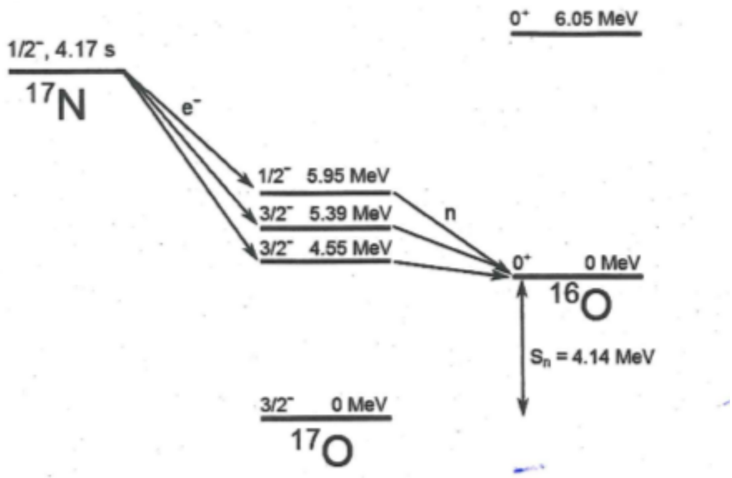

Figure 3: β-delayed neutron emission from ^{17}O