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Letter to the Editor

On the Nuclear Transformation ~~by~~ with the Absorption of the Orbital Electron

According to the present theory of β-disintegration, the nucleus of atomic number Z transforms into its isobar Z-1 with the emission of a positron and a neutrino, if the difference ΔW of proper energies of these isobares is larger than $mc^2+\mu c^2$, where m and μ are the masses of the electron and the neutrino respectively. On the contrary, the isobar Z-1 transforms into Z with the emission of an electron and an anti-neutrino, if ΔW is smaller than $-mc^2-\mu c^2$. ~~Further, if ΔW is larger than $-E$ c, E where E is the total energy of an orbital electron of the isobar Z, this isobar can change into Z-1 with the absorption~~ Further, the isobar Z can transform into Z-1 also by absorbing one of the orbital electrons and emitting ~~an~~ a neutrino, if ΔW is larger than $-E+\mu c^2$, where E is the total energy of ~~a~~ the orbital electron.

Thus, two isobares with consecutive atomic numbers are both stable only if ΔW lies between $-mc^2-\mu c^2$ and $-mc^2+\mu c^2$. This condition can be fulfiled very rarely, if the neutrino mass is small compared with the electron mass. Since the existence of several pairs of such stable nuclei was confirmed by the experiment recently,[1] it will be worth while to give a brief account of the results of our previous calculations on this subject.[2] ~~Moreover, in case~~ It should be noticed that, when ΔW is larger than $mc^2+\mu c^2$, the ~~relative importance of such the above process compared with the ordinary process of positron emission, which has some practical meanign, so that the ratio of the probabilities of these processes are will be shown~~ moreover it will be ~~important to~~ important to determine the ~~relative~~ ratio in various cases the above process and the ordinary positron emission will occur side by side with the above process, ~~the~~ so that the relative importance of these processes will also be discussed.

First, the mean life time τ of the nucleus Z due to the absorption of either of two K-electrons with $E = mc^2\sqrt{1-\alpha^2 Z^2}$ was calculated for the allowed transition without the change of the nuclear spin, where α was the fine structure constant. If the neutrino mass is assumed to be zero, τ is approximately proportional to

$$\frac{(\alpha Z)^{2\gamma+1}}{(\Delta w+\gamma)^2} \quad \text{or} \quad \frac{(\alpha Z)^{2\gamma+1}}{(\Delta w+\gamma)^4}$$

according as the coupling scheme of Fermi or Konopinski-Uhlenbeck is adopted, where

$$\Delta w = \frac{\Delta W}{mc^2} \qquad \gamma = \sqrt{1-\alpha^2 Z^2}$$

~~The third and the fourth columns of Table 1 show~~ The numerical values for several cases are shown in Table 1.

Table 1.

Z	αZ	τ (Fermi)		τ (K.-U.)	
1	1/137	2740 $(\Delta w+1)^{-2}$	years	1860 $(\Delta w+1)^{-4}$	years
~~1~~ 42	0.307	170 $(\Delta w+1)^{-2}$	years	120 6	years
14	0.1	200	days	130	days
27	0.2	25	days	16	days
69	0.5	14 $(\Delta w+0.87)^{-2}$	hours	8 $(\Delta w+0.87)^{-4}$	hours

The apparent discrepancy between these resultes and the existence of stable pairs of heavy isobares can be removed only if we assume ~~by assuming~~

i) the ~~large~~ difference of nuclear spins to be sufficiently large ~~enough for each~~ so as to make that pair of nuclei are ~~of stable in to be~~ practically stable,

ii) the neutrino mass to be comparable with the electron mass,

or

iii) the wave functions of the electron in the neighborhood of the nucleus to be much smaller than those calculated by Dirac's theory.

Next, the ratio σ of the probabilities of the positron emission and the K-electron absorption was calculated on similar assumptions as above, when ΔW is larger than $mc^2 + \mu c^2$, the numerical results being summarized in Table 2.

Table 2,

Z	αZ	ΔW	σ (Fermi)	σ (K.U.)
14	0.1	2	2.9	0.15
14	0.1	5	250	36
27	0.2	2	0.2	2.2×10^{-2}
27	0.2	5	20.7	3.1
82	0.6	2	~~0.8×10^{-3}~~ 0.1	2.5×10^{-5}
82	0.6	5		1.6×10^{-2} *

The transformation of the hydrogen atom into the neutron, which corresponds to the extreme case $Z=1$, will not occur actually, as the mass of the neutron is certainly larger than the summ of those of the electron and the proton according to the recent data. On the contrary, the case $Z=2$ has some practical importance indicating the spontaneous transformation of He^3 into H^3 by absorbing on the K-electrons.

* For ordinary radio-element emitting positrons, for which ~~α~~Z is small and ΔW is ~~larger than 2~~ about 5 or more, ~~so that the~~ the ratio σ is so large that the ~~disintegration~~ order of mean life time ~~does not change~~ are not changed by the absorption of the orbital electron in addition to this process. On the contrary, for large values of Z, ~~such a~~ this process ~~becomes~~ will occur much more frequently than the positron emission as long as ΔW is not too large compared with μc^2.