Letter to the Editor

On the Nuclear Transformation 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 $Z-1$ ~~Z of atomic nu~~ with the emission of a positron and a neutrino, if the difference ΔW of proper energies of these ~~ist~~ 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 μc^2-E, where E is the total energy of an orbital electron of the isobar Z, ~~the latter~~ this isobar can change into $Z-1$ with the absorption of the electron, a neutrino being emitted at the same time. 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 fulfilled ~~only~~ only very rarely, if the neutrino mass is small compared with the electron mass. Since the existence of several pairs of such stable isobares was confirmed by the experiment ~~, it is~~ recently[1], it will be permitted to give a brief account of the results of ~~our calculation of the mean life time of the isobar Z due to the~~ our previous ~~papers~~ calculations on this subject.[2] Moreover, in case when ΔW is larger than $mc^2+\mu c^2$, the isobar Z can transform into $Z-1$ with the ~~po~~ electron absorption as well as with the positron emission, so that the determination of the relative importance of these processes in various cases will be of some importance.

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First, the mean life time τ of the nucleus Z due to the absorption of either ~~two~~ K-electrons with $E = mc^2\sqrt{1-\alpha^2 Z^2}$ ~~were~~ τ was calculated for the allowed transition without the change of the nuclear spin, ~~the next~~ The columns of Table 1 show their ~~results~~ numerical values and for several ~~values of~~ Z, corresponding to the interactions of Fermi and Konopinski-Uhlenbeck types respectively, the neutrino mass μ being assumed to be zero[3])

(where α is the fine structure constant.)

Table 1.

Z	αZ	τ (F.)	τ (K.U.)
1	1/137	$2740\left(\frac{\Delta W}{mc^2}+1\right)^{-2}$ years	
2	2/137	$170\left(\frac{\Delta W}{mc^2}+1\right)^{-2}$ years	
14	0.1	$200\left(\frac{\Delta W}{mc^2}+1\right)^{-2}$ days	
27	0.2	$25\left(\frac{\Delta W}{mc^2}+1\right)^{-2}$ days	
69	0.5	$144\left(\frac{\Delta W}{mc^2}+0.87\right)^{-2}$ hours	

If ~~we assume~~ the ~~mean life time~~ neutrino mass is assumed to be zero, the mean life time is approximately proportional to

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

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

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

The apparent discrepancy between these results and the existence of stable pairs of heavy nuclei can be removed only if ~~one of the following assumption~~ assumptions ~~we assume~~ ~~condition~~ is made.

i) ~~the large~~ we assume the difference of nuclear spins for each pair of stable isobars, to be large the position emission and the K-electron absorption was calculated for several values of Z and ΔW in the case of allowed transition, the results being summarized in Table 2.

For ordinary radio-elements emitting positrons, for which αZ is small and ΔW is larger than $2mc^2$, the ratio σ is so large that the disintegration by the electron absorption of the orbital electrons does not affect seriously the mean life time. On the contrary, for large values of Z, such a process become much more frequent than the positron emission, as long as ΔW is not too large compared with mc^2.

+ The extreme case $Z=1$ corresponding to the transformation of the hydrogen atom into the neutron corresponding to the extreme case does not occur actually, as the difference of the masses of the neutron and the proton is larger than the mass of the electron found according to the recent experimental results. On the contrary, the case $Z=2$ has some practical importance indicating the spontaneous transformation of He^3 into H^3 by absorbing one of the K-electrons.

The mean life time becomes shorter as the atomic number increases, and the existence of . can be reconciled with this result only if . . .

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