

From Hydrogen Atoms to Neutrons

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Abstract: *Neutrons* are elementary particles that can decay into *protons*, *electrons*, and *neutrinos*. The inverse process, formation of neutrons from protons and electrons, has been explored in different directions. A way of generating neutrons from hydrogen atoms is considered here in connection with some assumptions developed in a previous paper.

Keywords: Bohr model, neutron, hydrogen atom.

Our starting point is the *Bohr model* of the *hydrogen atom*. Recall that in this model, an *electron* moves in a quantized circular orbit around a *proton*. If m denotes the *mass* of the electron, r the *radius* of its orbit and v the *speed* corresponding to the *quantization integer* n , we obtain the following relations:

$$F = \frac{ke^2}{r^2} = \frac{\alpha\hbar c}{r^2} = \frac{mv^2}{r}, mvr = n\hbar, E = -\frac{1}{2} \frac{ke^2}{r} = -\frac{1}{2} \frac{\alpha\hbar c}{r}$$

where k is the *Boltzmann's constant* and e the *elementary charge*. The constant $\alpha = \frac{ke^2}{\hbar c}$ is the *fine structure constant* and $\hbar = \frac{h}{2\pi}$ where h is the *Planck's constant*. From these relations, we get for the corresponding quantization integer n :

$$r(n) = \frac{1}{\alpha} \cdot \frac{\hbar}{mc} \cdot n^2, \quad v(n) = \alpha c \cdot \frac{1}{n}, \quad E(n) = -\frac{1}{2} m\alpha^2 c^2 \cdot \frac{1}{n^2}$$

For $n=1$, the orbit of the electron is called the *ground orbit* and its speed on this orbit is αc . For the other orbits, the speed of the electron depends on n and it is diminishing as n is increasing. However, the possibility of having orbits with greater speeds could be explored and this is done in the next sections.

In the following, we consider a model with an orbit below the ground orbit where we assume that the speed v of the electron is *superluminal* with $v = \sqrt{2}c$. Note that this kind of speed has already been mentioned in a previous paper¹ where a model of a five-dimensional universe is investigated and physical entities having superluminal velocities, in particular $v = \sqrt{2}c$, are considered. The following results are however independent of it.

Starting with a hydrogen atom in its *ground orbit*, we assume that its electron can jump into a lower orbit where its speed is $\sqrt{2}c$. Call this new orbit the *neutral orbit*. The result of this jump from the ground orbit to the neutral orbit is the

production of energy and we assume that this energy is transformed into mass which is added to the mass of the new atom or particle. Our computations show that this new resulting mass is approximately equal to the mass of the electron. What we get then is a new atom that can be considered as a new neutral particle with a mass approximately equal to that of a neutron. The above transformations can be considered as a *process of generating neutrons from hydrogen atoms* and in some way the reverse of the decay of a neutron into a proton and an electron.

We consider now the details of the above process when the electron of a hydrogen atom jumps from its ground orbit to its neutral orbit, its speed being then $v = \sqrt{2}c$. The relations for this neutral orbit can be described in the following way:

$$F_v = \frac{\alpha \hbar c}{r^2} = \frac{mv^2}{r} = \frac{2mc^2}{r}, \quad E_v = -\frac{1}{2} \frac{\alpha \hbar c}{r}$$

The relations for F_v and E_v are similar to the corresponding relations for the Bohr model where the speed $v = \alpha c$ has been replaced by $v = \sqrt{2}c$. From that we get:

$$r = \frac{1}{2} \frac{\alpha \hbar}{mc}, \quad E_v = -mc^2$$

Note that:

$$r = \frac{1}{2} \cdot \frac{\alpha \hbar}{mc} = \frac{1}{2} \frac{ke^2}{\hbar c} \cdot \frac{\hbar}{mc} = \frac{1}{2} \cdot \frac{ke^2}{mc^2} = r_e$$

where r_e is equal to what is called the *classical radius* of the electron.

The energy E_γ corresponding to the ground orbit in the Bohr model is given by $E_\gamma = -\frac{1}{2} m \alpha^2 c^2 = -mc^2 \cdot \frac{1}{2} \alpha^2$ with the value $E_\gamma = -13.6 \text{ eV}$. From that follows:

$$E_v = -mc^2 = \frac{2}{\alpha^2} \cdot E_\gamma$$

Taking for α^{-1} the value 137.0388, we get then:

$$E_v = -2 \times (137.0388)^2 \times 13.6 \text{ eV} = -510806 \text{ eV}$$

The energy $E_{\gamma v}$ liberated by jumping from the ground orbit to the neutral orbit is then:

$$E_{\gamma v} = E_\gamma - E_v = -13.6 + 510806 = 510792.4 \text{ eV}$$

Assuming now that this energy $E_{\gamma v}$ is converted into mass, the hydrogen atom is transformed into a new neutral particle P_v whose mass m_v is the sum of the mass of a proton, the mass of an electron and the mass $m_{\gamma v}$ obtained from the conversion of the energy $E_{\gamma v}$.

To compute the mass $m_{\gamma v}$, we use the atomic mass unit u and the conversion factor $u = 931 \text{ MeV}/c^2$. From $E_{\gamma v} = 0.5107924 \text{ MeV}$, we get then for the mass of

$m_{\gamma\nu}$ the value $m_{\gamma\nu} = 0.00054865 \text{ u}$. Taking the values $m_p = 1.00728$ for the proton and $m_e = 0.000549$ for the electron, we get then for m_ν :

$$m_p + m_e + m_{\gamma\nu} = 1.00728 + 0.000549 + 0.00054865 = 1.0083776 = m_\nu$$

Hence we get a neutral particle P_ν having a mass $m_\nu = 1.0083776$ approaching the mass 1.008665 of a neutron.

We can assume that some energy and hence some additional mass is brought into the system during the process of transformation of the hydrogen atom into the neutral particle P_ν and we can consider the above process as a way of generating neutrons.

Hence we can state:

Given a hydrogen atom, the jump of its electron from the ground orbit to the neutral orbit produces an energy E_ν . Assuming that this energy is transformed into mass, we get a new neutral particle whose mass is obtained from the combination of the masses of the proton, the electron of the original atom and the one created from the energy E_ν . Since the mass of this new particle is closed to that of a neutron, the above process can then be considered as a way of formation of neutrons.

References:

1. Gabriel Thierrin, "[Space, Time and Big Bang: An Alternative Interpretation](#)," *Comprehensive Theory Articles, Journal of Theoretics, Vol. 3-4, 2001.*

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