QUARKS, NUCLEI and BORON-10 NEUTRON CAPTURE

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ABSTRACT

The quark make-up of protons and neutrons is discussed. Neutrons that give protons and electrons must be composed of "Combo Up or Down" quarks. The neutral baryons of stable nuclei do not contain "Combo quarks". An alpha particle containing a "Combo quark" is not the same as an electron-stripped He-4 atom which contains none. Since the mass of Up and Down quarks constitute less than 1% of the total mass of baryons, the remainder mass of these must be non-particulate mass, herein called "fat". Dumbbell models of the stable positive and neutral baryons are presented. Using these baryonic dumbbells, the extraordinary ability of the Boron-10 nucleus to capture neutrons is modeled.

Keywords: quarks, baryons, protons, neutrons, nuclei of elements, neutron capture, Standard Model, baryonic dumbbells, combination quarks, nuclear mass, quark mass, alpha particle

INTRODUCTION

After neutrons were discovered[1], it was soon found that they decayed into protons and electrons.

$$n = p^+ + e^- + \text{energy} \quad (1)$$

In 1956, Cowan and Reines[2] demonstrated that the energy was in the form of a neutrino. In 1964, Gell-Mann and Zweig[3] proposed that the basic components of protons and neutrons were quarks. The introduction of quarks, which have actually been detected[4], led to the Standard model[5]. While there have been many more particles introduced, neutrons and protons are still presented as combinations of Up and Down quarks[6]. Up quarks are designated as having +2/3 charge and Down quarks having -1/3 charge to make the mathematics work. The old equation now becomes more graphic with quarks and Feynman diagrams.

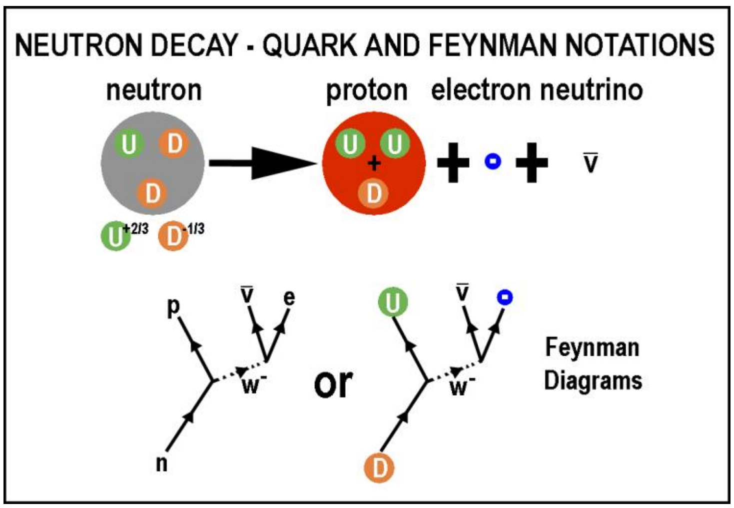

Figure 1. Current quark and Feynman notations for the decay of a neutron.

The imagery in still accepted after nearly half a century. So, what could be wrong?

- Firstly, Up and Down quarks are supposed to be unique and singular. Thus, having a Down quark give an Up quark plus some other stuff is irrational.
- Secondly, why doesn't the Down quark of the proton decay? Unlike a neutron, which has a lifetime of ~880 seconds[7], a proton has a lifetime longer than 10^{34} years[8]. A proton's lifetime is therefore about $7x10^{23}$ times longer than the universe's estimated age[9], a number slightly greater than an Avogadro's binary mole (2^{79})[10]! The total mass of the earth's hydrosphere[11] is $1.4x10^{24}$ g and therefore about 10^{24} protons. You're not likely to be in the right place, if one should decay.
- Thirdly, many of the elements of the periodic table are quite stable, in spite of having many "neutrons".

Recent studies at Jefferson Lab indicate that two Up and Down quarks pair up in protons and neutrons and leave the 3rd dangling[12]. They indicate that paired quarks can have different behavior than the single. Diquarks have not been confirmed nor dismissed, yet, so the nature of the quarking of the baryons is still a bit unsettled. This paper will focus on the current Standard Model view and the application of the triad quarks to some nuclei and to neutron capture.

DISCUSSION

The current Standard Model as presented in Figure 1 must be wrong. A neutron must not be made up of an Up quark and 2 Down quarks. To be consistent with Up and Down quarks being "singular and unique", a neutron must be made up either of 1 Up quark, 1 Down quark and a combo of an Up quark with an electron and a neutrino (Option A - closer to the current) or 2 Up quarks and a combo of a Down quark with an electron and a neutrino (Option B). The mathematically correct representations are shown in Figures 2 and 3. Up and Down quarks are stable as indicated by the stability of the proton. In neither case is the unstable quark a stable Down quark as implied in the Standard Model. This might be the reason for the JLab results. Of course, it also indicates the problem of being able to distinguish the difference between combo quarks and simple ones of the same charge.

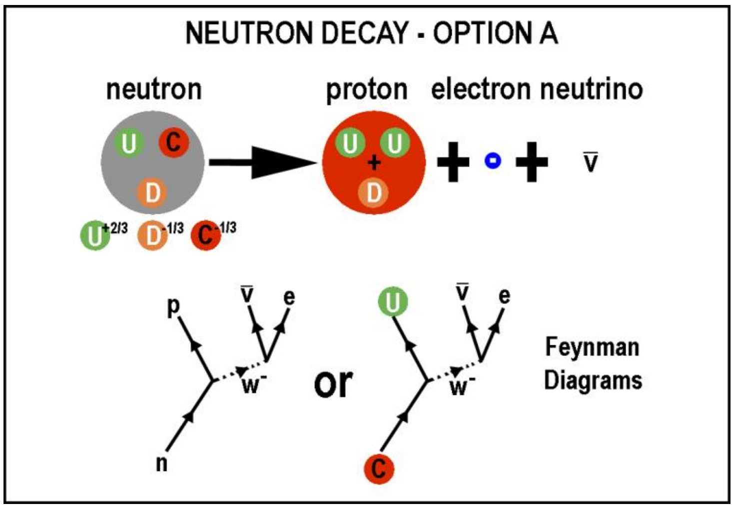

Figure 2. Neutron Decay Option A: Conversion of a combo component to an Up quark.

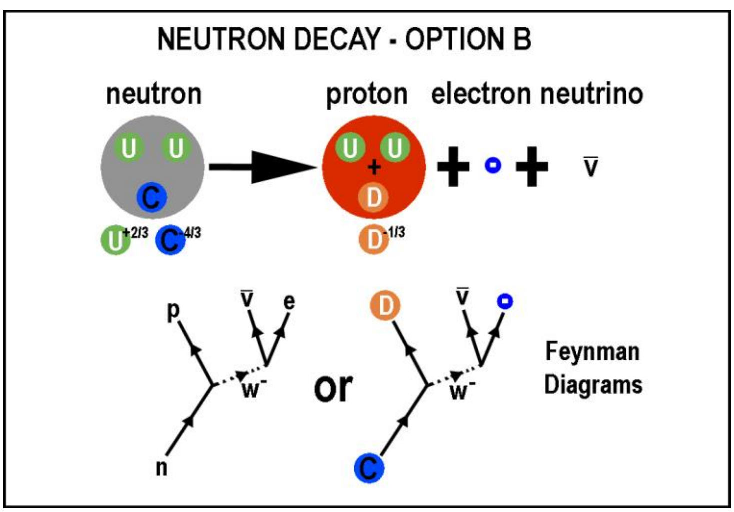

Figure 3. Neutron Decay Option B: Conversion of a combo component to a Down quark.

Both forms of the neutron would seem logical. The stability of the Up-combo and the Down-combo might be an issue, however. Why? Well, one could deliver the results when neutron decay is observed and the other could be the means to more stable, but still radioactive nuclei. Also, a Down-Up-Down assemblage of quarks, where the Downs are not combos with electrons, should give a stable neutral baryon, nee "nuclear neutron".

RAMIFICATIONS FOR THE NUCLEI OF THE ELEMENTS

Assuming that Up and Down quarks[4] are the only "particle" constituents of a proton, it seems logical that they must surrounded by "fat" within the nuclear confinement. This can be represented by the following equation:

$$(\mathbf{U_{fat} + U_{fat} + D_{fat}})_{\text{proton nucleus}} \quad = \quad (\mathbf{U_{lean} + U_{lean} + D_{lean} + \text{"fat"}})_{\text{proton nucleus}} \qquad \mathbf{(2)}$$

And, if quarks can be fat and lean, then it is reasonable to assume that leptons can also be. Thus, neutron decay becomes

$$(\mathbf{U_{fat} + C_{fat} + D_{fat}})_{\text{neutron nucleus}} \rightarrow (\mathbf{U_{fat} + U_{fat} + D_{fat}})_{\text{proton nucleus}} + \mathbf{W_{fat}} \qquad \mathbf{(3a)}$$

or

$$(\mathbf{U_{fat} + U_{fat} + C_{fat}})_{\text{neutron nucleus}} \rightarrow (\mathbf{U_{fat} + U_{fat} + D_{fat}})_{\text{proton nucleus}} + \mathbf{W_{fat}} \qquad \mathbf{(3b)}$$

with

$$\mathbf{W_{fat} = (e_{fat} + v_{fat})} \sim\sim\sim\sim\sim\sim\sim\sim\sim\sim\!\longrightarrow \mathbf{e_{lean} + v_{lean} + \text{"fat"}} \qquad \mathbf{(4)}$$

"Fat" must be non-particulate, non-descript "mass". How much "fat"? For a proton, the "fat" is 106 times the mass of the quark sum (0.938% of the total and experimentally observed[13]!). Since a neutron's mass is 0.001388 greater than that of a proton, this is W_{fat}. Thus, the "fat" around the electron adds 0.00084 or 53.1% to the mass of the electron when in the nucleus, assuming there is little fat around the neutrino. How that "fat' is manifested is another matter.

The emphasis of high-energy research has been to delve deeper and deeper into the nucleus. Modeling has thus been on the simplest: proton and neutron and smaller. Most of the naturally occurring elements of the periodic table have very long lifetimes. Other than hydrogen, these elements have more mass than can be attributed to the protons alone. The extra mass is thus attributed to neutrons which add no charge. Considering the lifetime of a neutron, some other explanation is needed. Indeed, a "nuclear sphere" of proton and neutron balls seems rather far fetched anyway. Considering that a proton is quite stable with Up and Down quarks, it would seem that other stable nuclei are simply coordinated arrangements of these two stable quarks and their "fat" without the Combo with electrons. Extra "fat" is needed as the nuclear "body" grows. As an example, consider the nuclei of deuterium, tritium, helium, and mercury.

stable $(\mathbf{3U_{lean} + 3D_{lean} + \text{"fat"}})_{\text{deuterium nucleus}}$ **(5)**

whereas

unstable $(\mathbf{4U_{lean} + C_{up\ lean} + 4D_{lean} + \text{"fat"}})_{\text{tritium nucleus}} \rightarrow (\mathbf{5U + 4D + \text{"fat"}})_{\text{He-3 nucleus}} + \mathbf{1e}$ **(6)**

or

$(\mathbf{5U_{lean} + 3D_{lean} + C_{down\ lean} + \text{"fat"}})_{\text{tritium nucleus}} \rightarrow (\mathbf{5U + 4D + \text{"fat"}})_{\text{He-3 nucleus}} + \mathbf{1e}$ **(7)**

stable $(\mathbf{6U_{lean} + 6D_{lean} + \text{"fat"}})_{\text{He-4 nucleus}}$ **(8)**

stable $(\mathbf{280U_{lean} + 320D_{lean} + \text{"fat"}})_{\text{Hg-80 nucleus for mass 200 (80p+120"stable n")}}$ **(9)**

Consider that, if quarks are actually grouped in triads, the positive triads (protons) and neutral triads ("stable neutrons") would likely be dumbbell-shaped as depicted in Figure 4. Can you imagine crystal–like networks – with and without flaws? Can you imagine how 80 UDU and 120 DUD dumbbells could be logically assembled for the Hg-200 nucleus? How about simple, minimal energy, arrangements of 600, individual, stable quarks? Since radioactive tritium has a half-life of 12.3 years[14] (441,000 x that of an "unstable neutron"), combo quarks can form pseudo stable nuclei. Can a non-radioactive H-3 (tritium) exist in analogy to He-3?

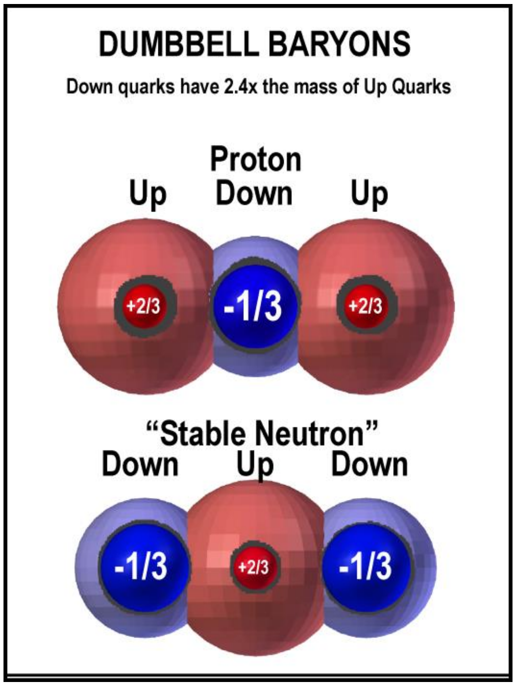

Figure 4: Dumbbell shapes for positive and neutral baryons.

NEUTRON CAPTURE

An interesting behavior of some nuclei is their ability to capture neutrons. In this realm, few nuclei rival that of Boron-10 and the only naturally occurring ones better at it are rare earth elements and Cadmium[15]. This light mass element has a neutron cross-section 1000 to 100,000 times bigger than a "barn" (a barn is the size of a Uranium nucleus[16]) when capturing low energy neutrons[17].

$$\textbf{Boron-10}^{5+} + \textbf{n} \quad \rightarrow \quad \textbf{Li-7}^{3+} + \textbf{Alpha Particle}^{2+} \qquad \textbf{(10)}$$

The natural occurrence of Boron-10 and the facileness of this reaction allow it to be considered in low energy neutron cancer therapy[18].

The reaction seems simple enough, but what is the reason for Boron-10's unusual ability to capture neutrons? A low-energy transition pathway involving a loose and easily deformed nuclear mass would provide an excellent answer. The modeling in Figure 5 of the interaction of a possible Boron-10 nucleus with a neutron is based on the foregoing discussion of dumbbell baryons forming nuclei. With arrows to indicate baryon movement, it should be easy to follow the capture and conversion to observed products. Refer to Figure 4 for the shapes of the positive (proton) and negative (neutron) baryons, if necessary. The effectiveness of a softer punch (lower energy) by the approaching neutron should be clear. If the neutron is of the "combo" variety, the alpha particle will not be the same as He-4 stripped of its electrons. If it is of the "stable" Down variety, it will be.

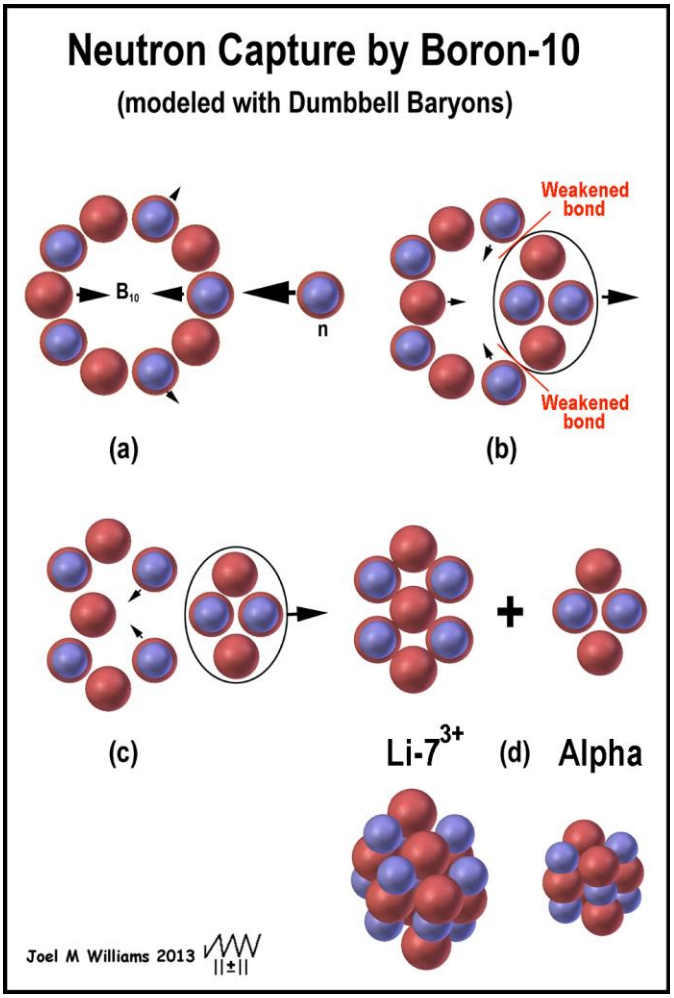

Figure 5. An explanation of the ease of neutron capture by a Boron-10 nucleus

Just as the electrons form orbital structures around a nucleus, a nucleus will have its components arranged in as minimal an energy configuration as possible. Whenever unstable "quark combos" or voids are formed to achieve these minimal-energy states, nuclear instability will follow. Also, a nuclear configuration will not emit a uniform field of electromagnetism. This will then influence the behavior of the electrons swarming around the nucleus.

SUMMARY

Neutrons that give protons and electrons must contain a "Combo Up or Down" quark. Neutral baryons of stable nuclei contain stable Up and Down quarks and no "Combo quarks". An alpha particle containing a "Combo quark" is not the same as an electron-striped He-4 atom. Up and Down quarks constitute less than 1% of the total mass of baryons; the remainder mass of these must be non-descript, non-particle mass, herein called "fat". The triads of individual positive and neutral baryons form complementary barbell units with distribution of mass and electrostatic charge that facilitate nesting. The interaction of these dumbbells provides a mechanism for easy capture of neutrons by the Boron-10 nucleus.

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