New Light into the Obscure Nature of Dark Matter

This paper is concerned with the prediction of a new particle with a mass of approximately $55.6\, eV/c^2$ *. This prediction is based on a new equation that I call: the fermionic "alpha" formula. This hypothetical particle could be either a new type of neutrino or a completely new type of neutral particle with sufficiently large abundance to account for most of the observed dark matter content of the Universe.*

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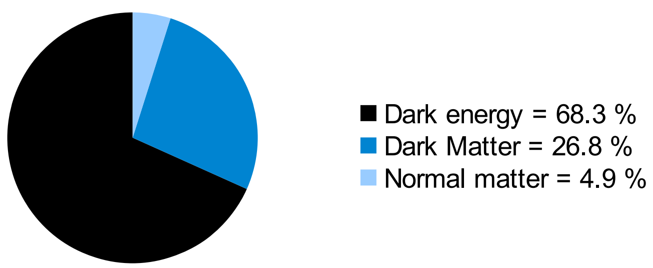
1. Introduction

Astronomical observations indicate that there is about 5.5 times more mass in clusters of galaxies than we would expect from the normal mass of the clusters and hot gas we can detect. Since clusters of galaxies are the largest known structures in the Universe and since most of the mass that makes up these clusters cannot be seen with telescopes, it is logical to assume that most of the matter in the Universe is *dark matter*: an invisible and electrically neutral material of unknown nature. The latest measurements indicate that the contents of the Universe is as depicted by the following pie chart



The hypothesis I shall put forward in this paper considers the following possibilities: a) there is, at least, one more type of neutrino (sterile and/or non-sterile). This new neutrino is massive and extremely abundant (much more abundant that the normal neutrinos), b) there is, at least, one new type of neutral particle other than a neutrino which is massive and extremely abundant (much more abundant that the normal neutrinos) and c) both previous possibilities are true. Note that if all neutrinos, including the unknown ones, and all unknown neutral particles which are not neutrinos have even a tiny mass each, they could add considerably to the overall dark matter of the Universe. Appendix 1 shows how to convert the rest mass of a particle into rest energy and viceversa.

2. Nomenclature

I shall use the following nomenclature for the constants used in this paper

α = fine-structure constant, electromagnetic coupling constant, or atomic structure constant.
m_n = neutron rest mass
m_p = proton rest mass
m_e = electron rest mass
m_x = rest mass of the unknown electrically neutral particle
K = dimensionless constant of the fermionic "Alpha" formula
$F_{JeV} = 1.602\ 176\ 564 \times 10^{-19}\ J/eV$ = conversion factor from Joules to electron-volts
$F_{JMeV} = 1.602\ 176\ 564 \times 10^{-13}\ \dfrac{J}{MeV}$ = conversion factor from Joules to Mega electron-volts

3. The Fermionic "Alpha" Formula

The fermionic "Alpha" formula is given by the following expression

$$\alpha \approx \frac{20}{\pi - 2}\left(\frac{m_n - m_p - m_e}{m_n + m_p + m_e}\right) \tag{3.1}$$

If we define the dimensionless constant *K* as

$$K \equiv \frac{20}{\pi - 2} \approx 17.519\ 383\ 94 \tag{3.2}$$

Now we can rewrite equation (3.1) in terms of *K*

$$\alpha \approx K\left(\frac{m_n - m_p - m_e}{m_n + m_p + m_e}\right) \tag{3.3}$$

The value this formula yields is

$$\alpha \approx 0.007\ 296\ 834\ 53 \tag{R1}$$

According to NIST, the value of the electromagnetic coupling constant is

$$\alpha_{NIST\ 2010} \approx 0.007\ 297\ 352\ 569\ 8\,(24) \approx 0.007\ 297\ 352\ 57$$

The fact that the value of formula (3.1) is accurate to 5 decimal places seems to indicate that: a) the formula is not numeric, and b) there is something missing in the formula that, if included, would make it exact. In the following section I shall find the missing parameter.

4. The "Hunt" for an Elusive Particle

The fermionic "Alpha" formula (3.3), which is an approximate formula, can be turned into an exact formula using three different methods. These methods are: **Method I)** by changing the value of the constant *K*. **Method II)** by adding term masses inside the parenthesis. **Method III)** by combining methods I and II. This formulation assumes that the value of the constant *K* given in the previous section is correct, therefore I propose that what is missing in equation (3.1 or 3.3) is the mass of an unknown particle. Thus, if we were able to include the missing mass, we would obtain an exact formula. There are only two physically valid ways of including this mass:

Case 1: The first way is by adding another mass term to both the numerator and the denominator of equation (3.1).
Case 2: The second way is by adding another mass term to the numerator only.

All the other cases will produce a negative value for the missing mass and therefore must be discarded. For symmetry reasons (two neutral particles and two charged particles) the missing mass must correspond to a neutral particle. We shall denote this mass with m_x . (Because we shall find that the value of this mass is extremely small, it is very likely that this mass corresponds to a new type of neutrino). Now we shall consider the above cases separately.

Case 1: The complete "alpha" formula corresponding to this case is

$$\alpha = \frac{20}{\pi - 2} \left(\frac{m_n + m_x - m_p - m_e}{m_n + m_x + m_p + m_e} \right) \tag{4.1}$$

And the solution to this equation is

$$m_x = \frac{m_n - m_p - m_e - \alpha \left(\frac{\pi - 2}{20} \right) \left(m_n + m_p + m_e \right)}{\frac{\alpha \pi}{20} - \frac{2 \alpha}{20} - 1} \tag{4.2}$$

The value for this mass is

$$m_x \approx 9.908\ 749\ 731 \times 10^{-35} Kg \tag{R2 a}$$

or, equivalently

$$m_x \approx 55.58 \frac{eV}{c^2} \tag{R2 b}$$

To have an idea of this mass let us calculate the following ratio

$$\frac{m_x}{m_e} = 0.000\,108\,8$$

This means that this mass is almost 1/10,000 lighter than the electron (more accurately: 1/9,193.3).

Case 2: The complete "alpha" formula corresponding to this case is

$$\alpha = \frac{20}{\pi - 2}\left(\frac{m_n + m_x - m_p - m_e}{m_n + m_p + m_e}\right) \tag{4.3}$$

If we solve this equation for m_x we get

$$m_x = \alpha\left(\frac{\pi - 2}{20}\right)(m_n + m_p + m_e) - (m_n - m_p - m_e) \tag{4.4}$$

The value for this mass is

$$m_x \approx 9.904\,622\,437 \times 10^{-35}\,Kg \qquad \text{(R3 a)}$$

or

$$m_x \approx 55.56\frac{eV}{c^2} \qquad \text{(R3 b)}$$

Note that this result is almost identical to the one we got for **case 1**. Therefore we conclude that the mass of this hypothetical particle is about $55.6\; eV/c^2$.

5. Brief Analysis

The mass we obtained in the two previous cases is bigger than the mass of the electron neutrino and, perhaps, smaller than the mass of muon neutrino (we know from quantum mechanics that, at least, one flavour of neutrino must be massive). This suggests that this new mass corresponds to a new type of neutrino. Because the Standard Model does not predicts the existence of any particle with this mass, we have to look into new theories. Thus, the possible candidates are:

(1) **Leptoquark neutrino**
The leptoquark theory, developed by J. A. Gowen [1], proposes the existence of neutral leptoquarks that would have decayed soon after the Big Bang into a leptoquark neutrinos and other decay products. Because leptoquaks are thought to be heavier than neutrons, the corresponding leptoquak neutrino should be heavier than the electron neutrino, and this is exactly what the formulation presented in this paper predicts.

(2) **Sterile neutrino**
Our hypothetical particle could be a sterile neutrino that was not part of the decay product of a leptoquark.

(3) **Non-sterile neutrino**
Our hypothetical particle could be a non-sterile neutrino that was not part of the decay product of a leptoquark. If this is correct, then there would be another generation of matter (also known as family of matter).

(4) **New type of particle.**
Our hypothetical particle could be a new extremely light neutral particle which would not classify neither as a neutrino nor as a hadron. I believe that this is a less likely possibility, however it should not be discarded. Note that this new particle, with a mass of approximately $55.6\, eV/c^2$, could not be a superlight lepton (a lepton lighter than the electron) because leptons carry an electrical charge and charged particles, as far as I know, cannot explain the properties of dark matter. However superlight negatively charged leptons, such as electrinos, can exist as part of the decay product of the electron [2].

6. Conclusions

This formulation predicts an elusive new particle with a mass of, approximately, $55.6\, eV/c^2$. This formulation also predicts that the abundance of this new particle is sufficiently large to exceed that of all the known neutrinos together and to account for a considerable part of the overall dark matter of the Universe. This theory – if proven correct – could explain the dark matter mystery, at least, to a large extent.

Appendix 1
How to Convert the Rest Mass of a particle into Rest Energy and Viceversa

a) How to Convert the Rest Mass of a particle in *Kg* into Rest Energy in *MeV*

The conversion formula is

$$E_0(MeV) = \frac{m_0(Kg)\times c^2}{1.602\,176\,564\times 10^{-13}\,\dfrac{J}{MeV}} \qquad \text{(A1)}$$

Example

To convert the neutron rest mass, m_n , to energy, in *MeV*, we apply the above formula (A1)

$$E_0(MeV) = \frac{1.674\,927\,292\times 10^{-27}\,Kg\times\left(299\,792\,458\,\dfrac{m}{S}\right)^2}{1.602\,176\,564\times 10^{-13}\,\dfrac{J}{MeV}} = 939.565\,379\,1\,MeV$$

Usually the rest mass of a particle (in this case for the neutron rest mass) is expressed as

$$m_n(MeV/c^2) = 939.565\ 379\ 1\ \frac{MeV}{c^2}$$

b) How to Convert the Rest Energy of a particle in *MeV* into Rest Mass in *Kg*

The conversion formula is

$$m_0(Kg) = \frac{E_0(MeV) \times 1.602\ 176\ 564 \times 10^{-13} \frac{J}{MeV}}{c^2} \qquad \text{(A2)}$$

Example

To convert the rest energy, in *MeV*, of a neutron to its equivalent rest mass, m_n , in *Kg* we apply the above formula (A2)

$$m_0(Kg) = \frac{939.565\ 379\ 1\ MeV \times 1.602\,176\,564 \times 10^{-13} \frac{J}{MeV}}{\left(299\ 792\ 458 \frac{m}{S}\right)^2} = 1.674\ 927\ 351 \times 10^{-27}\ Kg$$

which is the rest mass of the neutron in *Kg*.

REFERENCES

[1] J. A. Gowen, *Symmetry Principles of the Unified Field Theory (a "Theory of Everything") - Part I*, html document retrieved 2008 from the web, (2007).

[2] R. A. Frino, *Is the Electron Unstable?*, vixra.org: 1502.0194, (2015)