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Hypotheses on Nuclear Physics and Quantum Mechanics: A New Perspective

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Abstract The purpose of this study is to bring out new approach for determining the distance between each nucleon in a nucleus, explain why nuclear force is a short range force, and why electrostatic force has greater range than magnetic force, predict the structure of Helium-4 nucleus through different tests, and combine four different energies equations—nuclear energy equation, magnetic potential energy equation, electrostatic energy equation, and gravitational energy equation to form one energy equation, which is the *net energy* of the nucleus.In this study mathematical models were used to arrive at various experimental results, and new equations were developed, which can be used to predict the net energy of the nucleus, the self energy of every nucleon, the energy released during nuclear fission, the size of the atom, and the contraction of the nucleons in any nucleus.

Keywords Nuclear Physics

1. Introduction

Various attempts have been made in the past to determine the size of the nucleus (Geoff, 2010), as well as unify all the fundamental forces and elementary particles to be written in terms of a single field (Hubert, 2004).

The great accomplishment by others in determining the radius of the proton, its magnetic moment and mass will be of tremendous benefit in this study (Mohr, 2011).

The nuclear binding energy equation may not be used to predict the centre-to-centre distance between each proton and neutron in a nucleus; neither can the electrostatic energy equation account for the energy released in the fission of Uranium-235 (Gopal, 2010). Magnetic potential energy equation cannot be used to determine the energy of the revolving electron; and gravitational energy is the weakest of these forces in the nucleus.

A proper understanding of these forces/energies acting in the nucleus in terms of their range and strength is needed for precise prediction to be made on the effect of these forces/energies within and outside the nucleus (Varadarajan, 2004). These forces which all act in the nucleus will be used in determining the centre-to-centre distance apart between each neutron and proton in the nucleus, the atomic radius of revolving electron, the energy released in the fission of Uranium-235, the net energy of every nucleus system, and the contraction of the nucleons which leads to a loss in mass in the nucleus.

This study help bring together four different energies equations—nuclear energy equation, magnetic potential energy equation, electrostatic energy equation, and gravitational energy equation to form one energy equation, which is the *net energy* of the nucleus.

In this study mathematical models were used to arrive at various experimental results (Billings, 2013), and new equations were developed, which can be used to predict the net energy of the nucleus, the self energy of every nucleon, the energy released during nuclear fission, the size of the atom, and the contraction of the nucleons in any nucleus

2. Test for the Structure of Helium-4 Nucleus

Fundamental Knowledge/Mathematical Derivations

Some basic knowledge of orbiting bodies in gravitational field is needed here. From gravitational law the velocity of a satellite around an orbit is given by:

$$V_o = \sqrt{g^i R} \quad (1.1)$$

$$V_o = \sqrt{\frac{g r_m \times r_1}{r_m^2}} \quad (1.2)$$

$$V_o = \sqrt{\frac{g r_1}{r_m}} \quad (1.3)$$

Where g^i = acceleration due to gravity at that orbit
g = gravity of the orbited body at its surface

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R = centre radius apart between orbited body and satellite
r_m = Multiple of force producer radius to distance apart
r_1 = force producer radius

Escape velocity at any orbit,

$$V_{eo} = \sqrt{2g'R} = \sqrt{\frac{2gr_1}{r_m}} \quad (1.4)$$

From $$V_{eo} = \sqrt{\frac{2gr_1}{r_m}} = \frac{V_e}{\sqrt{r_m}}$$

$$\therefore\ V_{eo} = \frac{V_e}{\sqrt{r_m}} \quad (1.5)$$

V_e-escape velocity at surface of force producer

Also, $V_o = \sqrt{\frac{gr_1}{r_m}}$

Which is $\sqrt{2}$ times less than V_{eo}

$$\therefore\ V_o = \frac{\sqrt{2gr_1}}{\sqrt{2r_m}} = \frac{\sqrt{2gr_1}}{\sqrt{2}\times\sqrt{r_m}} = \frac{V_e}{\sqrt{2r_m}}$$

V_0 – orbiting velocity round the earth

$$V_o = \frac{V_e}{\sqrt{2r_m}} \quad (1.6)$$

$$V_{eo} = \frac{V_e}{\sqrt{r_m}} \quad (1.7)$$

Kinetic energy of an orbiting body

$$K.E_o = \frac{mv^2}{2} \quad (1.8)$$

$$K.E_o = \frac{m}{2}V_o^2 = \frac{m}{2}\left(\frac{V_e}{\sqrt{2r_m}}\right)^2$$

Where V = V_o and M- mass of orbiting body

$$\frac{MV_e^2}{2\times 2r_m} = \frac{MV_e^2}{4r_m} \quad (1.9)$$

The least energy it will use to escape that orbit is

$$K.E_{eo} = \frac{mv^2}{2}$$

here V = V_{eo}

$$K.E_{eo} = \frac{mV_{eo}^2}{2} = \frac{m}{2}\left(\frac{V_e}{\sqrt{r_m}}\right)^2$$

$$= \frac{mV_e^2}{2r_m} \quad (1.9.1)$$

Table 1.1. Relationship between Vo, Veo, rm, K.Eo, and K.Eeo

$V_o = \frac{V_e}{\sqrt{2r_m}}$	$K.E_o = \frac{mV_e^2}{4r_m}$
$V_{eo} = \frac{V_e}{\sqrt{r_m}}$	$K.E_{eo} = \frac{mV_e^2}{2r_m}$

When two bodies are almost of similar weight, it is impossible for one to orbit the other.

When like poles of magnets are placed near each other, both repel themselves and escape at the least escape velocity around that orbit.

If two magnets M_1 and M_2 of different poles are attracted to each other at a distance apart, M_2 of different poles are attracted to spring balances at a distance apart, M_2 will record more reading on the spring balance if its mass is less than M_1. This means that M_2 is more likely to move towards M_1 at the velocity around M_1 orbit.

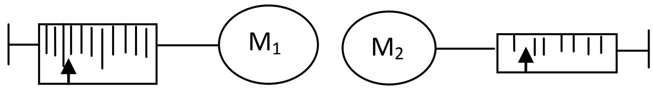


Figure 1.1. Extension of spring under magnetic field

With this basic knowledge the nuclear binding energy can be studied.

Nuclear force is a short range force (like magnetic force is short range) that exists between proton-proton, proton-neutron, and neutron-neutron.

Nuclear energy is the energy required to split the nucleus of an atom into its component part. It is the binding energy.

The protons of hydrogen combine to helium only if they have enough velocity to overcome each other's mutual repulsion sufficiently to get within range of the strong nuclear attraction.

The Potential Energy (P.E) of an object at any point from the centre of the earth is given by

$$P.E = mg^iR \quad (1.9.2)$$

But $$g^iR = \frac{V_{eo}^2}{2}$$

$$\text{And } Mg^iR = M\frac{V_{eo}^2}{2} \quad (1.9.3)$$

$M\frac{V_{eo}^2}{2}$ is the least energy it will use to escape that orbit.

Therefore the P.E of any system is equal to the least energy needed to separate the system.

For two magnets of like poles, the energy needed to separate them is equal to their P.E and the magnets will move at a velocity away from each other, which is equal to the escape velocity at that orbit.

A body may be considered a system if no external force is acting on it, or if external force does not have effect on it.

Total Energy in a system: the Binding Energy

Consider a system to be formed of N magnets having equal masses, and the distance between any two closest magnets is the same. The binding energy or P.E for all the bodies is the total energy used to hold them together.

Total Binding energy

$$E_B = E_b\ (N-1) \quad (1.9.4)$$

Where E_B = total binding energy
E_b = binding energy between any two magnet
N = total number of magnets

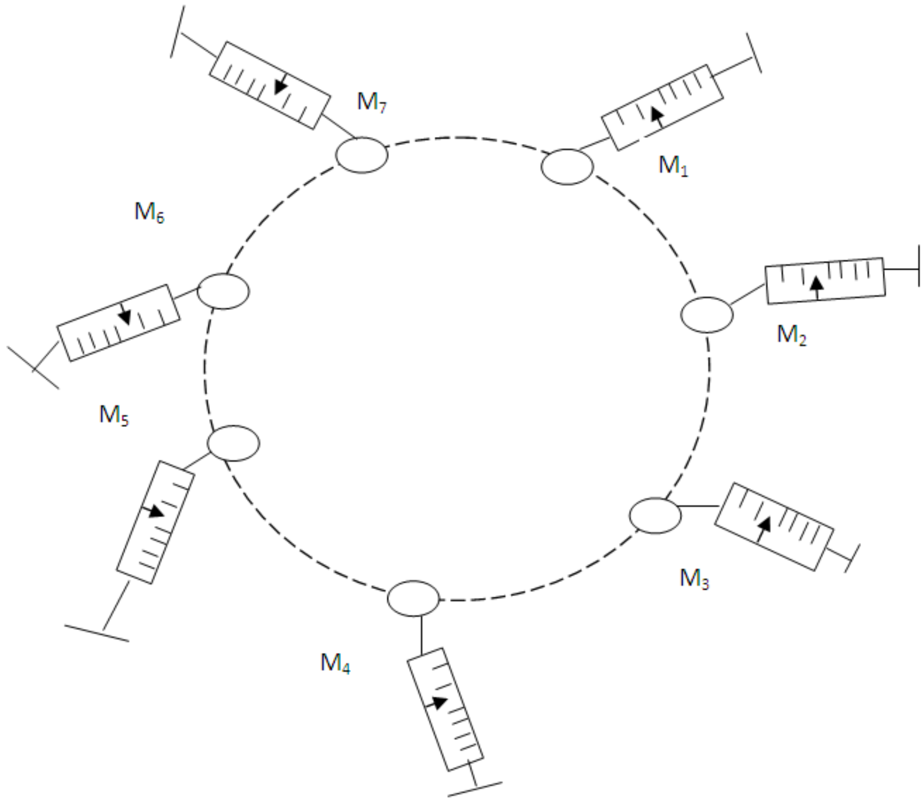


Figure 1.2. Multiple magnets in a force field

i.e $E_B = \frac{M_1 V_{eo}^2}{2}(N-1) = \frac{M_1 V_e^2}{2r_m}$ (N-1) (1.9.5)

r_m – multiple of radius of one magnet with the distance between the closest magnet
V_e – escape velocity at r_1
V_{eo} – escape velocity at r_1 x r_m = R

This basic knowledge will be used in dealing with the binding energy of various nucleuses of elements.

A nucleus will be considered a close system since no external force is acting on it. The electrostatic force between revolving electrons do not affect the position of the nucleus because of the greater weight of the nucleus.

In the nucleus system, the proton which has a mass slightly lesser than the neutron is used as the object because the force acting on it is the least force needed to separate the system.

Fundamental knowledge of electrostatic potential energy is also required. The electrostatic potential energy between the electron and the proton if the electron is on the surface of the proton is:

$$E_E = \frac{q^2(N-1)}{4\pi\epsilon_o R} \quad (1.9.6)$$

Where N- total number of charge

R = r_1 x r_m

$r_1 = 0.8775\times 10^{-15}m$

And r_m = 1

E_E – total electrostatic potential

$= \frac{(1.6\times10^{-19})^2\times(2-1)}{4\pi\epsilon_o\times(0.8775\times10^{-15})}$

= 2.62564×10^{-13}J

$$\frac{E_E}{(N-1)} = \frac{M_e V_e^2}{2r_m}$$

where Me – mass of electron

The escape velocity of electron at proton surface is

$$V_e = \sqrt{\frac{2r_m E_E}{M_e(N-1)}} \quad (1.9.7)$$

$$V_e = \sqrt{\frac{2\times1\times(2.62564\times10^{-13})}{(9.1\times10^{-31})\times(2-1)}} = 7.6\times10^8 m/s$$

V_e = 2.53 x the speed of light = 2.53C

From Bohr's theory on atomic model, the electron at the lowest energy level of a hydrogen atom has energy of 13.6eV (21.8 x 10^{-19}J). This energy is the energy of the orbiting electron (E_0)

$$E_0 = \frac{M_e V_0^2}{2} \quad (1.9.8)$$

$$V_o = \sqrt{\frac{2E_o}{M_e}} = \sqrt{\frac{2\times(21.8\times10^{-19})}{9.1\times10^{-31}}} = 2.19 \times 10^6 m/s$$

From $V_o = \frac{V_e}{\sqrt{2r_m}}$

$$(2.19\times10^6)^2 = \frac{(2.53C)^2}{2\times r_m}$$

$$r_m = \frac{(2.53C)^2}{(2.19 \times 10^6)^2 \times 2} = 6 \times 10^4$$

R= $r_1 \times r_m = (0.877\,5 \times 10^{-15}) \times (6 \times 10^4)$= 5.27 x 10^{-11}m

This is the centre radius between the orbiting electron and the proton in a hydrogen atom – or the radius of the hydrogen atom.

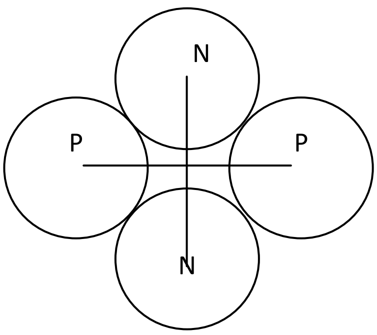
Mathematical Models for Helium-4 Structure

Helium-4 nucleus is extremely stable. To know the structure of this nucleus, some possible outcome of its structure will be subjected to two different tests:

a. Atomic Radius Test
b. Nuclear Fission (electromagnetic potential) Energy Test

P – Proton
N – Neutron

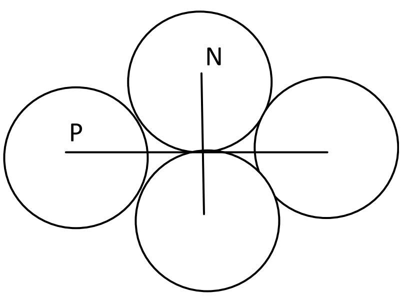
Model i)



Here P-P = $3.33r_1$
N-N = $2.43r_1$
P-N = $2r_1$

Figure 2.1. Model I

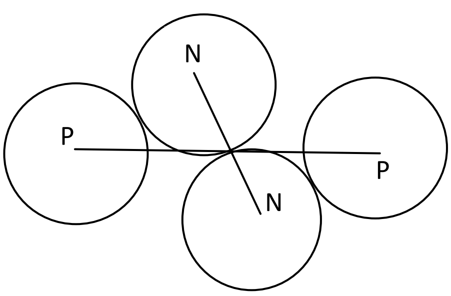
Model ii)



Here P-P = $3.67r_1$
N-N = $3r_1$
P-N = $2r_1$

Figure 2.2. Model II

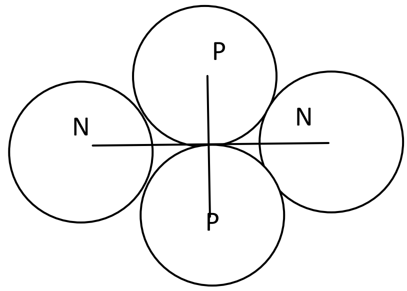
Model iii)



Here P-P = $4r_1$
N-N = $2r_1$
P-N = $2r_1$

Figure 2.3. Model III

Model iv)



Here P-P = $2r_1$
N-N = $3.67r_1$
P-N = $2r_1$

Figure 2.4. Model IV

Test A: Atomic Radius Test

Using Mercury as a case study:

Mercury – N = 201; n_p = 80; n_n = 121

Where N - number of protons and neutrons in the nucleus
n_p – number of protons in the nucleus
n_n – number of neutrons in the nucleus

Atomic mass M_2 = 200.9703023u; Lowest energy level or ground state of the electron = 10.4eV; empirical atomic radius Ra= 1.51 x 10^{-10}m

$$E_{o=}\frac{M_e V_0^2}{2}[E_o = 10.4eV = 1.664\,X\,10^{-18}\text{J}]$$

$$1.664 \times 10^{-18} = \frac{(9.1 \times 10^{-18})\,V_0^2}{2}$$

$$V_o = \sqrt{\frac{2 \times (1.664 \times 10^{-18})}{9.1 \times 10^{-31}}} = 1912366\text{m/s}$$

Atomic nucleus radius

$$R_n = r_o N^{\frac{1}{3}} \qquad (2.1)$$

This formula is used for heavier nuclei (N>20); where r_o = 1.2 – 1.5fm; and N- total number of protons and neutrons in the nucleus.

$$R_n = (1.3 \text{ x } 10^{-15}) \times \sqrt[3]{201} = 7.615 \times 10^{-15}m$$

r_m between electron orbit and nucleus = $\frac{R_a}{R_n}$ (2.2)

$$r_m = \frac{1.51 \times 10^{-10}}{7.615 \times 10^{-15}}$$
= 19829

Test B: Nuclear Fission Energy Test

In nuclear fission, the absorption of a neutron by a heavy nuclide (e.g U-235) causes the nuclide to become unstable and break into light nuclides and additional neutrons. This positively charged light nuclide then repel, releasing electromagnetic potential energy.

$_{92}U^{235} + {_0}n^1 \longrightarrow {_{92}}U^{236}{_{56}} \longrightarrow Ba^{141} + {_{36}}Kr^{92} + 3{_0}n^1 + \text{Energy}$

The fission of one atom of U-235 generates 202.5 MeV = 3.24 x10^{-11}J

The Helium-4 model must meet these criterion or have values that are near r_m = 19829 and E_r = 3.24 x 10^{-11}J

(Where E_r = energy released).

Model I

Test A: At $r_{pp} = 3.33r_1$ for the helium nucleus where r_{pp} = p-p distance.

Then from

$\frac{E_B}{(N-1)} = \frac{M_p V_e^2}{2r_{pp}}$ where M_p = mass of proton

Helium-4 has atomic mass of 4.00260325415U = 6.64648 x10^{-27}kg

Actual mass of 2 protons + 2 electrons + 2 neutrons = 6.697 x 10^{-27}kg

Mass loss $\Delta M = (6.697 \times 10^{-27}) - (6.64648 \times 10^{-27})$

= 5.052 x 10^{-29}kg

Total Binding Energy

$$E_B = \Delta MC^2 = (5.052 \times 10^{-27}) \times (3 \times 10^8)^2$$

= 4.547 x 10^{12}J

$$\frac{E_B}{(N-1)} = \frac{M_p V_e^2}{2r_{pp}}$$

Number of nucleons in Helium-4 is 4

$$\frac{E_B}{(4-1)} = \frac{M_p V_e^2}{2 \times 3.33}$$

$$V_e^2 = \frac{6.66E_B}{3M_p}$$

$$V_e = \sqrt{\frac{6.66E_B}{3M_p}} = \sqrt{\frac{6.66 \times (4.547 \times 10^{-12})}{3 \times (1.67262178 \times 10^{-27})}}$$

$$V_e = 77685522 m/s = \frac{c}{3.862}$$

$$V_e^2 = \frac{C^2}{14.9}$$

$$\frac{E_B}{(N-1)} = \frac{M_p V_e^2}{2r_{pp}} = \frac{M_p}{2r_{pp}} \times \left(\frac{C^2}{14.9}\right) = \frac{M_p C^2}{29.83r_{pp}} \doteq \frac{M_p C^2}{30r_{pp}}$$

$$\frac{\Delta mc^2}{(N-1)} = \frac{M_p C^2}{30r_{pp}}$$

$$r_{pp} = \frac{M_p(N-1)}{30\Delta m} \quad (2.3)$$

Using this formula, the distance between any two closest protons in a mercury nucleus can be determined.

Actual mass of 80 protons + 80 electrons + 121 neutrons in a Mercury–201 atom = 1.338097424 x 10^{-25} + 7.28 x10^{-29}+ 2.026662094 x 10^{-25}

M_1 = 3.365487518 x 10^{-25}kg

Actual mass of mercury–201 =200.9703023U = 3.3372 x 10^{-25}kg

$\Delta M = M_1 - M_2$ = 3.365487518 x 10^{-25} – 3.3372 x 10^{-25}

= 2.83 x 10^{-27} kg

$$r_{pp} = \frac{M_p(N-1)}{30\Delta m} = \frac{(1.67262178 \times 10^{-27}) \times (201-1)}{30 \times (2.83 \times 10^{-27})}$$

$$r_{pp} = 3.94$$

Radius between any two closest proton in a mercury-201nucleus is given by

R = $r_{pp} \times r_1$ = 3.94 x (0.8775 x 10^{-15})

= 3.45754 x 10^{-15}m

If an electron is brought to the mercury nucleus, and placed 3.45754 x 10^{-15}m away from any proton, thereby increasing the total number of charge of the nucleus, then the electrostatic energy of the nucleus will be:

$$E_E = \frac{q^2(N_{pe} - 1)}{4\pi\epsilon_o R}$$

Where N_{pe} – total number of protons + 1 electron added to the nucleus

$$E_E = \frac{(1.6 \times 10^{-19})^2 \times (81-1)}{4\pi\epsilon_o \times (3.45754 \times 10^{-15})} = 5.331 \times 10^{-12} J$$

Energy between a proton and this electron:

$$\frac{E_E}{(N_{pe} - 1)} = \frac{M_e V_{eo}^2}{2}$$

Velocity the electron will use to escape from this distance of 3.45754 x10^{-15}m from the closest proton:

$$V_{eo} = \sqrt{\frac{2E_E}{M_e(N_{pe}-1)}} = \sqrt{\frac{2 \times 5.331 \times 10^{-12}}{9.1 \times 10^{-31} \times (81-1)}}$$

= 382694246m/s

Since this velocity is the velocity at the nucleus, it can be regarded as the escape velocity V_e when compared to that used by the electron to orbit the nucleus 1.51 x 10^{-10}m away.

$$V_0 = \frac{V_e}{\sqrt{2r_m}}$$

$$r_m = \frac{V_e^2}{2V_o^2}$$

Recall that the velocity of the orbiting electron in Mercury–201 atom is 1912366m/s

$$r_m = \frac{V_e^2}{2V_o^2} = \frac{(382694246)^2}{2 \times (1912366)^2} = 20023$$

Radius of atom R_a = Radius of nucleus $\times r_m$

= r_n x r_m

= $\sqrt[3]{201}$ x (1.3 x 10^{-15}) x 20023

= 1.525 x10^{-10}m

This compares well with the known 1.51 x 10^{-10}m (empirical radius)

Test B: Nuclear fission (Electromagnetic potential) Energy Test

Energy released = Electromagnetic potential energy in nucleus

The nucleus in question here is Uranium–235, whose isotope mass number is 235.0439299U = 3.903 x 10^{-25}kg, atomic number = 92; number of neutron = 143

Actual mass of 92 protons + 92 electrons + 143 neutrons

M_1 = 3.9348 x 10^{-25}kg

Mass loss $\Delta m = M_1 - M_2$ = (3.9348 x 10^{-25}) – (3.903 x10^{-25}) = 3.179535 x 10^{-27}Kg

$$r_{pp} = \frac{M_p(N-1)}{30\Delta M} = \frac{(1.67262178 \times 10^{-27}) \times (235-1)}{30 \times (3.179535 \times 10^{-27})}$$

$$r_{pp} = 4.1$$

Radius between any two closest protons in the nucleus

R = r_{pp} xr$_1$

R = 4.1 x (0.8775 x 10^{-15}) = 3.6 x 10^{-15}m

Electrostatic energy $E_E = \frac{q^2(N_p-1)}{4\pi\epsilon_o R}$

$= \frac{(1.6 \times 10^{-19})^2 \times (92-1)}{4\pi\epsilon_o \times (3.6\times 10^{-15})}$

= 5.823 x 10^{-12}J

Magnetic potential Energy

$$E_m = m^\theta B \quad (2.4)$$

Where m^θ = magnetic moment of a proton, which is equal to 1.410606743 x 10^{-26}J/T

$$B = \text{magnetic field strength} = \frac{mv}{qR} \quad (2.5)$$

From electrostatic energy, Vat distance R is

$$\frac{E_e}{(N_p-1)} = \frac{M_p V^2}{2}$$

$$V = \sqrt{\frac{2E_E}{(N_p-1)M_p}}$$

$$V = \sqrt{\frac{2 \times (5.823 \times 10^{-12})}{(92-1) \times (1.67262178 \times 10^{-27})}}$$

V = 8747195m/s

Magnetic fields are produced by electric currents. The protons in a nucleus has magnetic properties because of the charge they carry. The electrostatic energy between the protons will cause them to move away from each other at a velocity (V which is equal to 8747195m/s for the uranium-235); thereby generating magnetic energy.

The magnetic field strength B = $\frac{M_p V}{qR}$

$$B = \frac{(1.67262178 \times 10^{-27}) \times (8747195)}{(1.6 \times 10^{-19}) \times (3.6 \times 10^{-15})}$$

$$B = 2.54 \times 10^{13}\,\text{T}$$

Since each proton repels the other 91 protons in the nucleus, the magnetic potential energy for the nucleus is given by

$E_m = [m^\theta B]$ (N_p-1)

= [(1.410606743 x 10^{-26} x (2.54 x 10^{13})] x (92-1)

= 3.26 x 10^{-11}J

This compares well with the 3.24 x 10^{-11}J energy released during fission of Uranium-235

Results

Table of Result for all the Models:

Table 2.1. Results for all models

Models	r_m	Radius of atom (m)	Magnetic potential energy (J)
I	20023	1.525x10^{-10}	3.26 x 10^{-11}
II	18021	1.37 x 10^{-10}m	2.78 x 10^{-11}
III	16677	1.27 x 10^{-10}m	2.48 x 10^{-11}
IV	33372	2.54 x x 10^{-10}	7 x 10^{-11}

Expected result: r_m = 19829; R_a = 1.51 x 10^{-10}m, and E_r = 3.24 x 10^{-11}J

Conclusions

From the various models of Helium-4 Nucleus Model I compares best with the known results of r_m = 19829, R_a = 1.51 x 10^{-10}m, and E_r = 3.24 x 10^{-11} J

From Model I Test II, it can be said that the energy released is the magnetic potential energy and not electrostatic potential energy or an addition of both.

Description of Model I: (Helium-4 Nucleus)

- The centre distance between the two proton in a Helium-4 nucleus is 3.33 x the radius of a proton
- The distance between any proton and the closest neutron is 2 × the radius of the proton
- The distance between the two neutrons is 2.43 x the radius of a proton
- The binding energy of Helium-4 nucleuses is 4.547 x 10^{-12}J
- The electrostatic potential energy is 7.885 x 10^{-14}J
- The magnetic potential energy is 4.9 x 10^{-13}J
- The centre distance between the farthest proton and neutron is 2 × the radius of a proton

From this model an equation for the N-N centre distance as well as the P-N centre distance can be written

N-N:

Where M_n- mass of neutron

N- number of nucleons =4

r_{nn} – 2.43

$$\frac{E_B}{(N-1)} = \frac{M_n V_e^2}{2r_{nn}}$$

E_B = 4.547 x 10^{-12}J

$$\frac{4.547 \times 10^{-12}}{(4-1)} = \frac{(1.67492735 \times 10^{-27}) \times V_e^2}{2 \times 2.43}$$

$$V_e = \sqrt{\frac{4.86 \times (4.547 \times 10^{-12})}{3 \times (1.67492735 \times 10^{-27})}} = 66316561\text{m/s}$$

$$V_e = \frac{c}{4.524}$$

$$V_e^2 = c^2/20.464$$

$$\frac{E_B}{(N-1)} = \frac{M_n V_e^2}{2r_{nn}} = \frac{M_n}{2r_{nn}} \times \left(\frac{c^2}{20.464}\right) = \frac{M_n c^2}{40.93 r_{nn}} \doteq \frac{M_n c^2}{41 r_{nn}}$$

$$\frac{\Delta m c^2}{(N-1)} = \frac{M_n c^2}{41 r_{nn}}$$

$$r_{nn} = \frac{M_n(N-1)}{41\Delta M} \quad (2.6)$$

P-N:

Where M_p- mass of Proton

N- number of nucleus

r_{pn} – 2

$$\frac{E_B}{(N-1)} = \frac{M_p V_e^2}{2r_{pn}}$$

$$\frac{4.547 \times 10^{-12}}{(4-1)} = \frac{(1.67262178 \times 10^{-27}) \times V_e^2}{2 \times 2}$$

$$V_e = \sqrt{\frac{4 \times (4.547 \times 10^{-12})}{(4-1) \times (1.67262178 \times 10^{-27})}} = 60205057\text{m/s}$$

$$V_e = \frac{c}{4.983}$$

$$V_e^2 = \frac{c^2}{24.83}$$

$$\frac{E_B}{(N-1)} = \frac{M_p c^2}{2r_{pn} \times 24.83} = \frac{M_p c^2}{49.66 r_{pn}} = \frac{M_p c^2}{49.66 r_{pn}} \doteq \frac{M_p c^2}{50 r_{pn}}$$

$$\frac{\Delta m c^2}{(N-1)} = \frac{M_p c^2}{50 r_{pn}}$$

$$r_{pn} = \frac{M_p\,(N-1)}{50\Delta m} \quad (2.7)$$

Table 2.2. Bond type and the binding energy of any nucleus

Bond type	Energy Equation
P-P	$E_B = \frac{M_p c^2}{30 r_{pp}}$
P-N	$E_B = \frac{M_p c^2}{50 r_{pn}}$
N-N	$E_B = \frac{M_n C^2}{41 r_{nn}}$

Centre–to–Centre Radii of the Nucleons of Some Elements

Using the formula

$r_{pn} = \frac{M_p(N-1)}{50\Delta m}$ for P-N centre distance

$r_{pp} = \frac{M_p(N-1)}{30\Delta m}$ for P-P centre distance

$r_{nn} = \frac{M_n(N-1)}{41\Delta m}$ for N-N centre distance

Note the distance $R = r_1 \times r_m$ where $r_m = r_{pp}$ or r_{pn} or r_{nn}

From the above table, it can be seen that P-N, P-P and N-N are closest at Iron–56. This means Iron-56 from the table above has the greatest bond between any two nucleons in the nucleus.

3. Hypothesis on Nuclear Forces

The binding energy between any two nucleons is given by

$$\frac{E_B}{(N-1)} = \frac{MV_{eo}^2}{2} = \frac{MV_e^2}{2r_m}$$

Where m = mass of the smaller nucleon and

$$r_m = r_{pp} \text{ or } r_{pn} \text{ or } r_{nn}$$

From Tab 2.3 one can look for the binding energy for each nucleus and find the relationship between them. It can be seen from the table that r_m is increasing.

A good relationship between the binding energy between any two nucleons in a nucleus and the distance apart will be used to formulate a new equation.

Mathematical Models:

i) Magnesium–24 has binding energy between any two closest proton and neutron

$$E_b = \frac{M_p C^2}{50 r_{pn}} = \frac{(1.67262178 \times 10^{-27}) \times (3 \times 10^8)^2}{50 \times 2.177}$$

$= 1.383 \times 10^{-12}$J

ii) Molybdenum–96 has binding energy between any two closest proton and neutron

$$E_b = \frac{M_p C^2}{50 r_{pn}} = \frac{(1.67262178 \times 10^{-27}) \times (3 \times 10^8)^2}{50 \times 2.146}$$

$= 1.403 \times 10^{-12}$J

iii) Uranium–238 has binding energy between any two closest proton and neutron

$$E_b = \frac{M_p C^2}{50 r_{pn}} = \frac{(1.67262178 \times 10^{-27}) \times (3 \times 10^8)^2}{50 \times 2.469}$$

$= 1.219 \times 10^{-12}$J

Table 2.3. Centre-to-centre radii of the nucleons of some elements

Elements	Atomic Number	number of nucleus	P-N	P-P	N-N
Lithium	3	7	2.869	4.782	3.504
Carbon	6	12	2.246	3.743	2.743
Magnesium	12	24	2.177	3.628	2.659
Iron	26	56	2.102	3.504	2.567
Molybdenum	42	96	2.146	3.576	2.621
Silver	47	108	2.177	3.628	2.658
Iodine	53	127	2.205	3.674	2.692
Tungsten	74	184	2.332	3.886	2.847
Gold	79	197	2.359	3.931	2.880
Uranium	92	238	2.469	4.114	3.015
Plutonium	94	244	2.484	4.139	3.033

Relationship:

$$E_b \propto \frac{1}{r_m}$$

$$E_{b1}r_{m1} = E_{b2}r_{m2}$$

Mathematical Model:

What is the centre-centre multiple distance for Iron-56 if the binding energy between any proton and neutron in an Iron-56 nucleus is 1.432 x 10^{-12}J. (Take binding energy of Magnesium-24 and centre–to–centre multiple of its closest proton and neutron to be 1.383 x 10^{-12}J and 2.177 respectively.)

$$E_{b1} = 1.383 \times 10^{-12}\text{J};$$

$$r_{m1} = 2.177;\ E_{b2} = 1.432 \times 10^{-12}\text{J};\ r_{m2} = ?$$

$$E_{b1}r_{m1} = E_{b2}r_{m2}$$

$$(1.383 \text{ x } 10^{-12}) \text{ x } 2.177 = (1.432 \text{ x } 10^{-12})\ r_{m2}$$

$$\frac{3.010791 \times 10^{-12}}{1.432 \times 10^{-12}} = r_{m2}$$

$$r_{m2} = 2.1025$$

This can be compared with 2.102 which is in the table.

Mathematical Model:

An unknown element has binding energy between two of its closest nucleons as 1.219 x 10^{-12}J, and the centre distance between the two nucleons is 2.469. What will be the binding energy between any two closest nucleons of Molybdenum-96, whose centre–to–centre distance multiple is 2.146

$E_{b1} = 1.219 \times 10^{-12}$J; $r_{m1} = 2.469$; $E_{b2} =$? $r_{m2} = 2.146$

$E_{b1}r_{m1} = E_{b2}r_{m2}$

(1.219 x 10^{-12}) x 2.469 = E_{b2} x (2.146)

$$E_{b2} = \frac{(1.219 \times 10^{-12}) \times (2.469)}{2.146} = 1.4025 \times 10^{-12}\text{J}$$

This compares well with the 1.403 x 10^{-12}J of the Molybdenum–96

Conclusion:

From the above, it can be concluded that the binding energy between any two nucleons is inversely proportional to their distance apart

$$E_b \propto \frac{1}{r_m}$$

Also the total binding energy in any nucleus is given by
$E_B = E_b$ (N-1)
Energy = force x Distance = FR

Hypothesis on Nuclear Forces states that

The force of attraction between any two nucleons held by nuclear forces, separated a distance R is proportional to the product of their masses and inversely proportional to the square root of their distance apart.

$$F_b \propto \frac{M_1M_2}{R^2} = \frac{N^BM_1M_2}{R^2} \quad (3.1)$$

Where N^B – nuclear constant, and varies for P-P, P-N and N-N

$$(N_{pp}^B, N_{pn}^B, N_{nn}^B)$$

Energy is needed to bring a mass from infinity to the point in question, R.

$$\text{Energy: } \frac{E_B}{(N-1)} = \frac{N^BM_1M_2 \times R}{R^2} = \frac{N^BM_1M_2}{R} \quad (3.2)$$

Recall that it was earlier stated that $E_b \propto \frac{1}{r_m}$

This present itself in a new form as:

$$\frac{N^BM_1M_2}{R}$$

where R= $r_m \times r_1$

Self Energy of Every Nucleon (E_{BS})

This is the self potential of every nucleon, and it is given by

$$E_{BS} = \frac{N^BM}{r_1} \quad (3.3)$$

Where r_1= radius of the nucleon

Using Helium-4 which is a very stable nucleus as a model, N^B can be gotten.

For P-P: Helium-4 $R_{pp} = r_1$ x r_{pp} = (0.8775 x 10^{-15}) x (3.33)

= 2.922075 x 10^{-15}m

E_B = 4.547 x 10^{-12}J; N = 4

$$\frac{E_B}{(N-1)} = \frac{N_{pp}^BM_1M_2}{R_{pp}}$$

$$\frac{4.547 \times 10^{-12}}{(4-1)} = \frac{N_{pp}^B(1.67262178 \times 10^{-27})^2}{2.922075 \times 10^{-15}}$$

$$N_{pp}^B = \frac{(2.922075 \times 10^{-15}) \times (4.547 \times 10^{-12})}{3 \times (1.67262178 \times 10^{-27})^2} =$$

= 1.5831 x 10^{27}Jm/kg^2

For P-N: $R_{pn} = r_1$ x r_{pn} = (0.8775 x 10^{-15}) x (2)

= 1.755 x 10^{-15}m

$$\frac{E_B}{(N-1)} = \frac{N_{pn}^BM_1M_2}{R_{pn}}$$

$$\frac{4.547 \times 10^{-12}}{(4-1)} = \frac{N_{pn}^B(1.67262178 \times 10^{-27}) \times (1.67492735 \times 10^{-27})}{(1.755 \times 10^{-15})}$$

$$N_{pn}^B = \frac{(1.755 \times 10^{-15}) \times (4.547 \times 10^{-12})}{3 \times (1.67262178 \times 10^{-27}) \times (1.67492735 \times 10^{-27})}$$

= 9.495 x 10^{26}Jm/kg^2

For N-N: $R_{nn} = r_1$ x r_{nn} = (0.8775 x 10^{-15}) x (2.43)

= 2.132325 x 10^{-15}m

$$\frac{E_B}{(N-1)} = \frac{N_{nn}^BM_1M_2}{R_{nn}}$$

$$\frac{4.547 \times 10^{-12}}{(4-1)} = \frac{N_{nn}^{B}(1.67492735 \times 10^{-27})^2}{2.132325 \times 10^{-15}}$$

$$N_{nn}^{B} = \frac{(4.547 \times 10^{-12}) \times (2.132325 \times 10^{-15})}{3 \times (1.67492735 \times 10^{-27})^2}$$

$= 1.152 \times 10^{27}$ Jm/kg^2

The nuclear force hypothesis when N> 2 for P-P, P-N and N-N

$$F_b = \frac{1.583 \times 10^{27} M_p^2}{R_{pp}^2} \text{ P-P} \quad (3.4)$$

$$F_b = \frac{9.495 \times 10^{26} M_n M_p}{R_{pn}^2} \quad \text{P-N} (3.5)$$

$$F_b = \frac{1.152 \times 10^{27} M_n^2}{R_{nn}^2} \quad \text{N-N} (3.6)$$

To know the energy between any two P-P or P-N or N-N, one multiply by R, so that $\frac{1}{R^2}$ becomes $\frac{1}{R}$

The total binding energy E_B of any nucleus is given by:

$$E_B = \frac{1.583 \times 10^{27} M_p^2}{R_{pp}} (N-1) = \frac{9.495 \times 10^{26} M_n M_p}{R_{pn}} (N-1) = \frac{1.152 \times 10^{27} M_n^2}{R_{nn}} (N-1)$$

Mathematical Model: What is the centre-to-centre distance between any two closest neutrons in Tungsten–184 nucleus? Binding energy of Tungsten nucleus is 2.3631 x 10^{-10}J.

From the hypothesis of nuclear forces, when N>2,

$$E_B = \frac{1.152 \times 10^{27} M_n^2 (N-1)}{R_{nn}}$$

$$2.3631 \times 10^{-10} = \frac{1.152 \times 10^{27} \times (1.67492735 \times 10^{-27})^2 \times (184-1)}{R_{nn}}$$

$$R_{nn} = \frac{1.152 \times 10^{27} \times (1.67492735 \times 10^{-27})^2 \times (183)}{2.3631 \times 10^{-10}}$$

$= 2.503 \times 10^{-15}$m

$R_{nn} = r_1 \times r_{nn}$

$$r_{nn} = \frac{R_{nn}}{r_1} = \frac{2.503 \times 10^{-15}}{(0.8775 \times 10^{-15})} = 2.852$$

This compares well with the 2.847 that is in Tab 2.3.

4. Hypothesis of Superior Forces / Energy

A charged particle at rest experiences a force in an electric field, but none in a magnetic field. A magnetic field doesn't speed up or slow down a particle: because it doesn't act on the parallel component of velocity, it only acts on the perpendicular component of velocity, so it can change the particle's direction.

Two instances can be sited:

i. A magnet placed near a beam of high velocity electrons moving in a straight line, causes the electrons to move in a circular path without altering the velocity of the electrons
ii. Planets are caused to orbit the sun because of the sun's magnetic field. The forces of the revolving planets are not altered by the magnetic field, but only the gravitational force is considered.

Added to these, electrons revolve round the nucleus under electrostatic force. The magnetic field that exist at the atomic level only cause the electron to move in circular path without slowing or increasing the velocity of the electron.

It was earlier proved that the energy released during nuclear fission of Uranium–235 is magnetic potential energy and not the small electrostatic potential energy which is

$\frac{3.26 \times 10^{-11}}{5.823 \times 10^{-12}}$ = 5.6 times smaller than the magnetic potential energy in the nucleus.

Neither is the energy released an addition of the magnetic and electrostatic potential energy.

In fact, the above three examples shows that the force of attraction on a revolving body is not a sum of the electrical and magnetic force or magnetic and gravitational force.

Mathematical Models to Prove that the Magnetic Potential Energy is Dominant than the Electrical Energy at the Nucleus

To prove why the magnetic field is dominant at the nucleus level, a simple nucleus (Hydrogen) shall be tested mathematically:

Hydrogen: N = 1, proton radius = r_1= 0.8775 x 10^{-15}-m, radius of atom $^{R}{}_{a}$ = 5.27 x 10^{-11}m

If a proton is placed near the proton (nucleus) of a hydrogen atom, at $2r_1$ away, then the electrostatic force of attraction will be

$$E_E = \frac{q^2(N-1)}{4\pi\varepsilon_o R} = \frac{(1.6 \times 10^{-19})^2 \times (2-1)}{4\pi\varepsilon_o \times (0.8775 \times 10^{-15}) \times 2}$$

= 1.3128 x 10^{-13}J

Again: $\frac{E_E}{(N-1)} = \frac{M_p V_{eo}^2}{2}$

The escape velocity of this proton is $V_{eo} = \sqrt{\frac{2E_E}{M_p(N-1)}}$

$$V_{eo} = \sqrt{\frac{2 \times 1.3128 \times 10^{-13}}{(1.67262178 \times 10^{-27}) \times (2-1)}} = 12528971 \text{m/s}$$

Also from

$$V_{eo} = \frac{V_e}{\sqrt{r_m}}$$

Note: From equation (2.2) $r_m = \frac{R_a}{r_1}$

At $2r_1$, V_{eo} = 12528971m/s is taken as the escape velocity V_e, so that

$$r_m = \frac{R_a}{2r_1} = \frac{5.27 \times 10^{-11}}{2 \times (0.8775 \times 10^{-15})} = 30028.5$$

From: $V_{eo} = \frac{V_e}{\sqrt{r_m}} = \frac{12528971}{\sqrt{30028.5}} = 72302\ m/s$

$$E_E = \frac{q^2(N-1)}{4\pi\varepsilon_o R} = \frac{(1.6 \times 10^{-19})^2 \times (2-1)}{4\pi\varepsilon_o \times (5.27 \times 10^{-11})}$$

$= 4.372 \times 10^{-18}$J

The Magnetic Potential Energy at both points

$E_m = [m^\theta B](N-1)$

Where m^θ = 1.41061 x 10^{-26}J/T

i) When r_m=2

R = r_l x r_m = (0.8775 x 10^{-15}) x 2 = 1.755 x 10^{-15}m

$B = \frac{M_p V}{qR} = \frac{(1.67262178 \times 10^{-27}) \times (12528971)}{(1.6 \times 10^{-19}) \times (1.755 \times 10^{-15})}$

B = 7.463 x 10^{13}T

$E_m = [m^\theta B](N-1)$

$= (1.41061 \times 10^{-26} \times 7.463 \times 10^{13}) \times (2-1)$

= 1.053 x 10^{-12}J

ii) When R = 5.27 x 10^{-11}m, V_{eo} = 72302m/s

$E_m = [m^\theta B](N-1)$

$B = \frac{M_p V}{qR} = \frac{(1.67262178 \times 10^{-27}) \times (72302)}{(1.6 \times 10^{-19}) \times (5.27 \times 10^{-11})}$

B = 14342256T

$E_m = [m^\theta B](N-1)$

$= (1.41061 \times 10^{-26} \times 14342256) \times (2-1)$

= 2 x 10^{-19}J

Results:

E_E at 1.755 x 10^{-15}m = 1.3128 x 10^{-13} J
and at 5.27 x 10^{-11}m = 4.372 x 10^{-18}J
E_m at 1.755 x 10^{-15} = 1.053 x 10^{-12}J
and at 5.27 x 10^{-11}m = 2 x 10^{-19}J

Conclusion: It is seen that the magnetic potential energy is greater than the electrostatic potential energy at the nucleus level, but at the atomic (radius) level the electrical energy is greater than the magnetic potential energy.

Hypothesis of Superior Forces/Energystates: The potential or kinetic energy possessed by a body under a non–contact (electric, magnetic, gravitational or nuclear) field is a measure of the superior force field.

Explanation: Beyond the atomic level magnetic force brings about bending effect, whereas gravitational and electrostatic force causes continuous movement.

Net Energy in the Nucleus

To know the net forces acting on any nucleus, it is assumed that the hypothesis of superior forces does not hold.

Next, the forces (or total force) acting on the nucleus is divided into two—attracting and repulsive forces.

The net force on the nucleus system is therefore

$$E_T = E_B + E_G - E_E - E_m \quad (4.1)$$

Table 4.1. Division of Forces in a Nucleus

Attracting Forces/Energy	Repulsive Forces/Energy
Nuclear force (E_B)	Electrostatic (E_E)
Gravitational Force (E_G)	Magnetic Force (E_m)

But when compared to the other forces/energy gravity is very weak at the atomic level.

Example: The gravitational energy between the protons in a Plutonium-94 nucleus is:

$$E_G = \frac{GM_1M_2}{R}(N_p - 1)$$

$$= \frac{(6.7 \times 10^{-11}) \times (1.67262178 \times 10^{-27})^2\ (94-1)}{(0.8775 \times 10^{-15}) \times 4.1339}$$

E_G = 4.806 x 10^{-48}J

This is negligible when compared with the electrostatic potential energy, which is:

$E_E = \frac{q^2(N_p - 1)}{4\pi\varepsilon \times R} = \frac{(1.6 \times 10^{-19})^2 \times (94-1)}{4\pi\varepsilon \times (0.8775 \times 10^{-15}) \times 4.1339}$
= 5.9 x 10^{-12}J

The new equation for the net energy then becomes:

$$E_T = E_B - E_E - E_m \quad (4.2)$$

$$E_T = \Delta Mc^2 - \left[\frac{q^2(N_p-1)}{4\pi\varepsilon_o R_{PP}}\right] - [m^\theta B](N_P - 1) \quad (4.3)$$

But $B = \frac{m_p V}{qR}$ and N_p = number of protons in nucleus

$$E_T = \Delta Mc^2 - \left[\frac{q^2(N_p-1)}{4\pi\varepsilon_o R_{PP}}\right] - \left[\frac{m^\theta M_p V_{eo}}{q \times R_{PP}}\right](N_P - 1) \quad (4.4)$$

But if the hypothesis of superior energy is put into consideration, the superior repulsive energy is E_m. Then the net Energy becomes:

$$E_T = \Delta Mc^2 - [m^\theta B](N_P - 1) \quad (4.5)$$

Summary of Net energy acting on nucleus with or without considering the Hypothesis of Superior Energy

Table 4.2. Net energy equation, with and without superior energy

Superior Energy	Without Superior Energy, and Gravity added
$E_T = \Delta Mc^2 - [m^\theta B] \times (N_P - 1)$	$E_T = \Delta Mc^2 - \left[\frac{q^2(N_p-1)}{4\pi\varepsilon_o R_{PP}}\right] - [m^\theta B] \times (N_P - 1) + \frac{GM_nM_p(N-1)}{R_{pn}}$

5. Hypothesis on Nucleons Contraction, Mass Loss and Binding Energy

The protons of hydrogen combine to helium only if they have enough velocity to overcome each other's mutual repulsion sufficiently to get within range of the strong nuclear attraction.

If two or more nucleons are to be brought together to be at a distance apart from each other, from Lorentz transformation, if they are brought together at a great speed, which can be compared with the speed of light c, then the length of the particles will appear to be less than its original length.

Mathematical Model

Using Lithium-7 as a case study:
$E_B = 6.2961 \times 10^{-12}$J, $R_{pn} = 2.5175475 \times 10^{-15}$m,
$r_{pn} = 2.869$,
$r_l = 0.8775 \times 10^{-15}$m

The potential (nuclear) energy holding the protons and neutrons in Lithium-7 nucleus is equal to the Kinetic energy at which they will separate.

$$\frac{E_B}{(N-1)} = \frac{M_p V_{eo}^2}{2} = \frac{N_{pn}^B M_p\, M_n}{R}$$

From Lorentz transformation, new length due to V is given by the equation:

$$l_2 = l_1 \times \sqrt{1 - {v^2}/{c^2}}$$

For the proton and neutron which has escape velocity compared to C, there will be a change in their radius, so that the new radius will be:

$$r_2 = r_1 \times \sqrt{1 - {v^2}/{c^2}}$$

Where V= escape velocity of the nucleon
r_l = original radius of the nucleon (proton or neutron)

From

$$\frac{E_B}{(N-1)} = \frac{M_p\, V_{eo}^2}{2}$$

$$V_{eo} = \sqrt{\frac{2E_B}{(N-1)M_p}} = \sqrt{\frac{2 \times (6.2961 \times 10^{-12})}{(7-1) \times (1.67262178 \times 10^{-27})}}$$

V_{eo}= 35422263 m/s

The new radius of the proton will be

$$r_2 = r_1 \times \sqrt{1 - {v^2}/{c^2}}$$

$$r_2 = (0.8775 \times 10^{-15}) \times \sqrt{1 - \frac{(35422263)^2}{(3 \times 10^8)^2}}$$

$= 0.8713616891 \times 10^{-15}$m

Change in radius $\Delta r = r_l - r_2 = (0.8775 \times 10^{-15}) - (0.8713616891 \times 10^{-15})$
$= 6.1383 \times 10^{-18}$m

But the total self energy of every nuclear in the nucleus is constant provided no external energy disturb or is acting on the system.

The self energy for one nucleon (proton): $E_{BS} = \frac{N_{pn}^B M_p}{r}$

Before change in radius = r_l
After change in radius = r_2

Before change in radius $E_{BS} = \frac{N_{pn}^B M_{p1}}{r_1}$:

From equation (3.5) when N>2, N_{pn}^B = 9.495 x 10^{26}Jm/Kg^2

$$\therefore E_{BS} = \frac{9.495 \times 10^{26} \times (1.67262178 \times 10^{-27})}{0.8775 \times 10^{-15}}$$

$E_{BS} = 1.809862541 \times 10^{15}$J

From Lorentz transformation there will be change in radius of the nucleus. This change in radius will lead to a change in mass for the self energy to remain constant since no external force is acting on the system.

So that

$$E_{BS} = \frac{N_{pn}^B M_{p2}}{r_2}$$

$$1.809862541 \times 10^{15} = \frac{9.495 \times 10^{26} \times M_{p2}}{0.8713616891 \times 10-15}$$

$$M_{p2} = \frac{(1.809862541 \times 10^{15}) \times (0.8713616891 \times 10^{-15})}{9.495 \times 10^{26}}$$

$M_{p2} = 1.660921412 \times 10^{-27} kg$

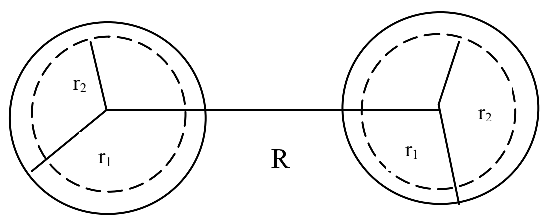
If (M_{pl}- M_{p2}) is the mass loss between the proton and neutron, total mass loss is given by

$\Delta M = (M_{pl} - M_{p2})(N-1)$
$= (1.67262178 \times 10^{-27} - 1.660921412 \times 10^{-27})(7-1)$
$= 7.020220515 \times 10^{-29} Kg$

Binding energy = $\Delta MC^2 = (7.020165619 \times 10^{-29}) \times (3 \times 10^8)^2$
$= 6.31815 \times 10^{-12}$J

This is in agreement with the accepted value 6.2960508 x 10^{-12}J

It is represented thus:



R = uncharged, but r_1 and r_2 changes

6. Reasons for Nuclear force Being Short Range

Mathematical Models

Using Mercury-201 as a case study, change in mass is 2.83×10^{-27}kg.

From equation (2.7) centre-centre radius apart between a proton and neutron in the nucleus is given by:

$r_{pn} = \frac{M_p\,(N-1)}{50\Delta m} = \frac{1.67262178^{-27} \times (201-1)}{50 \times (2.83 \times 10^{-27})} = 2.36413$

$R = r_{pn} \times r_1 = 2.36413 \times 0.8775 \times 10^{-15}$
$= 2.074523833 \times 10^{-15}$

Mercury-201 has its electron lowest energy level at 1.51 x 10^{-10}m which is 19829 ×the radius of the nucleus (7.615×10^{-15})

If a neutron is brought to the Mercury nucleus, and placed $2.074523833 \times 10^{-15}$m away from any proton, thereby increasing the mass of the nucleus, then the nuclear energy of the nucleus will be:

$$E_B = \frac{N_{pn}^{B}\, M_p M_n (N_{Nn}-1)}{R}$$

Where N_{Nn}--is the sum of the nucleons in the nucleus and the neutron added to it

$$E_B = \frac{9.495 \times 10^{26} \times (1.67262178 \times 10^{-27}) \times (1.67492735 \times 10^{-27}) \times (202-1)}{(2.074523833 \times 10^{-15})}$$

$= 2.577308 \times 10^{-10}$J

Energy between a proton and this neutron added to the nucleus:

$$\frac{E_B}{(N_{Nn}-1)} = \frac{M_n V_e^2}{2}$$

V_e is the velocity the added neutron will use to escape from the nucleus to 1.51×10^{-10}m away from the centre of the nucleus, which is the region with the lowest energy level of the electron.

$V_e = \sqrt{\frac{2E_B}{M_n(N_{Nn}-1)}} = \sqrt{\frac{2 \times 2.577308 \times 10^{-10}}{1.67492735 \times 10^{-27}\,(202-1)}}$
$= 39129306$m/s

But $V_{eo} = \frac{V_e}{\sqrt{r_m}}$

Recall that the radius multiple r_m, between Mercury-201 nucleus and its empirical atomic radius is 19829

Therefore, $V_{eo} = \frac{39129306}{\sqrt{19829}} = 277876$m/s

New radius of the neutron at a distance of 1.51×10^{-10}m will be:

$$r_2 = r_1 \times \sqrt{1 - v^2/c^2}$$

$r_2 = (0.8775 \times 10^{-15}) \times \sqrt{1 - \frac{(277876)^2}{(3 \times 10^8)^2}}$
$= 0.8774996236 \times 10^{-15} m$

Change in radius $\Delta r = r_1 - r_2 = (0.8775 \times 10^{-15}) - (0.8774996236 \times 10^{-15})$
$= 3.764248 \times 10^{-22}$m

To know the mass loss, we first find the self potential energy:

$E_{BS} = \frac{N_{pn}^{B} M_{n1}}{r_1} = \frac{9.495 \times 10^{26} \times (1.67492735 \times 10^{-27})}{(0.8775 \times 10^{-15})}$
$= 1.812357286 \times 10^{15}$

Also $E_{BS} = \frac{N_{pn}^{B} M_{n2}}{r_2}$

$1.812357286 \times 10^{15} = \frac{(9.495 \times 10^{26}) \times M_{p2}}{0.8774996236 \times 10^{-15}}$

$M_{p2} = \frac{(1.812357286 \times 10^{15}) \times (0.8774996236 \times 10^{-15})}{9.495 \times 10^{26}}$
$= 1.674926631 \times 10^{-27} kg$

Total change in mass = $M_{n1} - M_{n2}$ (N_{Nn}-1)
$= ((1.67492735 \times 10^{-27}) - (1.674926631 \times 10^{-27})) \times (202-1)$
$= 1.444853 \times 10^{-31}$kg

Binding Energy $E_B = \Delta Mc^2 = (1.444853 \times 10^{-31}) x (3 x 10^8)^2$
$= 1.3 x 10^{-14}$J

Solving for Δr and Δm when the added neutron is $2.074523833 \times 10^{-15}$m away from a proton in the nucleus:

Recall that the escape velocity at this point is 39129306m/s.

From Lorentz Transformation, $r_2 = r_1 \times \sqrt{1 - v^2/c^2}$

$r_2 = (0.8775 \times 10^{-15}) \times \sqrt{1 - \frac{(39129306)^2}{(3 \times 10^8)^2}}$
$= 0.8700038566 \times 10^{-15} m$

Change in radius $\Delta r = r_1 - r_2 = (0.8775 \times 10^{-15}) - (0.8700038566 \times 10^{-15})$
$= 7.496143445 \times 10^{-18}$m

To know the mass loss, we first find the self potential energy:

$$E_{BS} = \frac{N_{pn}^{B} M_{n1}}{r_1}$$
$$= \frac{9.495 \times 10^{26} \times (1.67492735 \times 10^{-27})}{(0.8775 \times 10^{-15})}$$
$$= 1.812357286 \times 10^{15}$$

Also $E_{BS} = \frac{N_{pn}^{B} M_{n2}}{r_2}$

$1.812357286 \times 10^{15} = \frac{(9.495 \times 10^{26}) \times M_{p2}}{0.8700038566 \times 10^{-15}}$

$M_{p2} = \frac{(1.812357286 \times 10^{15}) \times (0.8700038566 \times 10^{-15})}{9.495 \times 10^{26}}$
$= 1.660619093 \times 10^{-27} kg$

Total change in mass = $M_{n1} - M_{n2}$ (N_{Nn}-1)
$= ((1.67492735 \times 10^{-27}) - (1.660619093 \times 10^{-27})) \times (202-1)$
$= 2.87596 \times 10^{-27}$kg

Binding Energy $E_B = \Delta Mc^2 = (2.87596 \times 10^{-27}) x (3 x 10^8)^2$
$= 2.588364 x 10^{-10}$J

This binding energy is in agreement with the 2.577308 $\times 10^{-10}$J earlier gotten.

Results

Table 5.1. Change in mass, radius and velocity

At R= 2.074523833 $\times 10^{-15}$m			At R = 1.51× 10^{-10}m		
$\Delta r=r_1-r_2$ (m)	V_{eo}(m/s)	$\Delta m=m_1-m_2$ (kg)	$\Delta r=r_1-r_2$ (m)	V_{eo}(m/s)	$\Delta m = m_1-m_2$ (kg)
7.496143445 × 10^{-18}	39129306	2.87596 × 10^{-27}	3.764248 × 10^{-22}	277876	1.444853 × 10^{-31}

Conclusions

From Lorentz transformation:

i) When V is very small as compared to c, V^2/c^2 will be negligible in comparison to unity

Therefore, $M_1=M_2$ and $r_1=r_2$

ii) When V is comparable to c, then $\sqrt{1-v^2/c^2}$ will bring about a considerable change in mass and radius

Therefore $M_1> M_2$ and $r_1> r_2$

For two or more nucleons to be held by nuclear energy, they must be brought under high velocity that is, they will have enough velocity to overcome each other's repulsion (when there is more than one proton)

- There must be a considerable change in mass
- There must be a considerable change in radius of the nucleons
- The least velocity at which they will be separated after they are joined together, must be comparable to the speed of light

From the table of result above, it can be seen that the loss in mass, change in velocity and radius of the neutron when it is 1.51 $\times 10^{-10}$ m away is very small when compared to when it is 2.074523833 $\times 10^{-15}$m from the nearest proton.

7. Discussion: A New Perspective of the Nucleus

It was earlier said that nucleons contract under nuclear force and this lead to a change in mass in order to balance the self energy (potential) of every nucleon in a nucleus. The greater the nuclear binding energy the greater will be the contraction, as well as the loss in mass. The further apart the nucleons are from each other the less loss in mass, as well as the contraction of the nucleons.

If the contracted nucleons are separated outside the nuclear field, they may never regain their original radius. Thus:

i) The centre distance between any two closest nucleons may be unchanged, whereas their radii may change
ii) The nuclear self potential of any nucleon in a nucleus system is constant.

Physical Constant Used

To a good approximate, below are some constant used (all units are in S.I)

Proton Mass = 1.67262178 X 10^{-27}kg
Proton Charge radius = 0.8775X10^{-15}m
Proton Magnetic Moment = 1.410606743 X 10^{-26}J/T
Proton Charge = 1.6X10^{-19}C
Neutron radius = 0.8775 X 10^{-15}m
Electron charge = 1.6 X 10^{-19}C
Planck Constant = 6.626 X 10^{-34}JS
Neutron mass = 1.67492735 X 10^{-27}kg
Electron Mass = 9.1 X 10^{-31}Kg
Atomic Mass Unit = 1.66053892 X 10^{-27}Kg
Vacuum Permittivity ε_o= 8.854 X 10^{-12}F/m
Gravitational Constant = 6.7 × 10^{-11}Nm^2/kg^2

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