Title : **ELASTIC CONTINUUM THEORY**

OF

NUCLEON STRUCTURE & STRONG INTERACTIONS

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ABSTRACT

Based on the Elastic Continuum Theory[1], a new model for the nucleon structure has been introduced in this paper. Obtained as a cylindrically symmetric solution of elastic equilibrium equations, the nucleons are found to consist of an oscillating strain wave core. The strong interaction between two nucleons is computed through the axial as well as radial superposition of their cores. The strong interaction is shown to be sensitive to the relative orientation of intrinsic spins of interacting particles and not mediated by any meson or other particles. The positron and electron cores are also shown to interact strongly with the nucleon core resulting in the formation of proton and the neutron. Within the proton, the positron is shown to orbit in specific elliptical orbit, thereby giving rise to its magnetic moment. The nucleus is shown to mainly consist of layers of radially coupled deuterons arranged in hcp configuration.

Keywords. Nucleon core; Strong interactions; Strain bubbles; Positron; Neutron; Deuteron.

Theory and Observation : **'It may be heuristically useful to keep in mind what one has actually observed. But in principle it is quite wrong to try founding a theory on observable magnitudes alone. In reality, the very opposite happens. It is the theory which decides what we can observe... Observation is a very complicated process.'**

Albert Einstein

1. INTRODUCTION

1.1 The term nucleon refers to both protons and neutrons which are the main constituents of the atomic nucleus. The unique short range forces that bind nucleons so securely into nuclei, constitute the strongest class of forces, known as strong interactions. The range of strong interactions is understood to be of the order of 1.7×10^{-15} m or 1.7 f. Unfortunately nuclear forces are nowhere near as well understood as electrical forces and in consequence the theory of nuclear structure is still primitive as compared with the theory of atomic structure. Of course, tremendous progress has been made in the experimental and mathematical techniques employed to probe the inner details of the nucleus. The major experimental technique used in this regard is the scattering of high energy particle beams from the nucleus. Detailed interpretations of the results of scattering experiments can provide us with deep insight into the internal structural details of the nucleons. However, a proper and true interpretation of the results/observations demands prior knowledge of detailed interaction characteristics of the interacting particles involved in such scattering. Obviously the scattering experiments alone can not provide us complete information about the interaction characteristics as well as the structural details of the interacting particles, without making certain bold assumptions. One most bold assumption which has almost been taken for granted for more than half a century now, is the exchange theory of interactions. The second related assumption is regarding the range of validity of Coulomb interaction law, that it is assumed to be valid down to zero separation distance between the interacting charges. Third assumption implies that the electron and positron being point charges are not capable of taking part in strong interactions.

1.2 As per the Elastic Continuum Theory (ECT[1]) all interactions take place through the superposition of strain fields of interacting particles and are not mediated through the exchange of any particle whatsoever. Particle exchange might be the 'effect' or end result of certain interactions but never the cause of any. Therefore, for developing a model of nucleon structure and strong interactions based on ECT, we must abandon the approach followed in all such models which are based on exchange theory of interactions. Further in the model of Electron Structure & Coulomb Interaction[2] based on ECT, it has already been brought out that the electron and positron cores will interact mutually or with other strain bubble cores only through strong interactions. It is only the electron/positron strain wave fields that interact with other such fields through Coulomb interactions. Possibly therefore, the current interpretations of the results/observations of various nuclear scattering experiments may have to be revised or refined. The model of nucleon developed in this paper is based on a cylindrical strain bubble solution of equilibrium equations of elasticity in the Elastic Continuum. This strain bubble is stable, finite in size with cylindrical symmetry and oscillates at a frequency that matches with the oscillation frequency of electron/positron cores.

2. CYLINDRICAL STRAIN BUBBLES

2.1 Equilibrium Equations. As per ECT, our familiar space-time continuum, with characteristic properties of permittivity ε_0 and permeability μ_0, behaves as a perfect isotropic Elastic Continuum with elastic constant $1/\varepsilon_0$ and inertial constant μ_0 .

The equilibrium equations of elasticity written in terms of displacement vector **U** in this Continuum, turn out to be identical to the vector wave equation in electromagnetic theory. These equations in vector and tensor form are given below,

$$\partial^2\mathbf{U}/\partial x^2 + \partial^2\mathbf{U}/\partial y^2 + \partial^2\mathbf{U}/\partial z^2 = \nabla^2\mathbf{U} = (1/c^2)\,\partial^2\mathbf{U}/\partial t^2 \qquad \ldots\ldots\ldots..(1)$$

$$g^{11}u^i_{,11} + g^{22}u^i_{,22} + g^{33}u^i_{,33} = g^{jj}u^i_{,jj} = (1/c^2)\,\partial^2 u^i/\partial t^2 \qquad \ldots\ldots\ldots..\ (2)$$

where the displacement vector components u^i are functions of space & time coordinates referred to a coordinate system (y^1, y^2, y^3). The electromagnetic field in the so called 'vacuum' comes out to be a dynamic stress-strain field in the corresponding Elastic Continuum. A closed region of the Elastic Continuum with boundary surface Σ, that satisfies the specified boundary conditions and contains a finite amount of energy stored in its strain field, may be called a 'Strain Bubble'. From the nature of boundary conditions and the equilibrium equations, it turns out that all valid solutions for displacement vector components u^i are functions of space-time coordinates representing various types of strain wave oscillations. That is, all 'Strain Bubbles' contain a constant finite amount of total strain energy and essentially consist of various strain wave oscillations within a specific boundary surface Σ of the Elastic Continuum. One of the cylindrically symmetric solutions of equilibrium equations (2), represent the 'nucleon core' strain bubbles consisting of standing strain wave oscillations.

2.2 Solutions with Cylindrical Symmetry. Let us consider a cylindrical coordinate system defined by $y^1 = \rho$, $y^2 = \phi$ and $y^3 = z$, related to conventional Cartesian coordinates x, y, z as, $x = \rho\cos\phi$; $y = \rho\sin\phi$; $z = z$. The physical components u^ρ, u^ϕ, u^z of displacement vector **U** are related to the corresponding contravariant components u^1, u^2, u^3 as $u^\rho = u^1$; $u^\phi = \rho\, u^2$; $u^z = u^3$. The physical components of spatial strain in this coordinate system are

$$S^\rho_\rho = \frac{\partial u^\rho}{\partial \rho} \quad ; \quad S^\rho_\phi = \frac{1}{\rho}.\frac{\partial u^\rho}{\partial \phi} - \frac{u^\phi}{\rho} \quad ; \quad S^\rho_z = \frac{\partial u^\rho}{\partial z} \qquad \ldots\ldots\ldots(3A)$$

$$S^\phi_\rho = \frac{\partial u^\phi}{\partial \rho} \quad ; \quad S^\phi_\phi = \frac{1}{\rho}.\frac{\partial u^\phi}{\partial \phi} + \frac{u^\rho}{\rho} \quad ; \quad S^\phi_z = \frac{\partial u^\phi}{\partial z} \qquad \ldots\ldots\ldots(3B)$$

$$S^z_\rho = \frac{\partial u^z}{\partial \rho} \quad ; \quad S^z_\phi = \frac{1}{\rho}.\frac{\partial u^z}{\partial \phi} \quad ; \quad S^z_z = \frac{\partial u^z}{\partial z} \qquad \ldots\ldots\ldots(3C)$$

And the corresponding physical components of temporal strain are given by

$$S^\rho_t = \frac{1}{c}.\frac{\partial u^\rho}{\partial t} \quad ; \quad S^\phi_t = \frac{1}{c}.\frac{\partial u^\phi}{\partial t} \quad ; \quad S^z_t = \frac{1}{c}.\frac{\partial u^z}{\partial t} \qquad \ldots\ldots\ldots(3D)$$

For obtaining cylindrically symmetric solutions that are independent of ϕ coordinate, the dynamic equilibrium equations of elasticity can be written in cylindrical coordinates, in terms of physical components (u^ρ, u^ϕ, u^z) of displacement vector **U**, as follows

$$\frac{\partial^2 u^\rho}{\partial \rho^2} + \frac{1}{\rho}.\frac{\partial u^\rho}{\partial \rho} - \frac{u^\rho}{\rho^2} + \frac{\partial^2 u^\rho}{\partial z^2} = \frac{1}{c^2}.\frac{\partial^2 u^\rho}{\partial t^2} \qquad \text{..........(4A)}$$

$$\frac{\partial^2 u^\phi}{\partial \rho^2} + \frac{1}{\rho}.\frac{\partial u^\phi}{\partial \rho} - \frac{u^\phi}{\rho^2} + \frac{\partial^2 u^\phi}{\partial z^2} = \frac{1}{c^2}.\frac{\partial^2 u^\phi}{\partial t^2} \qquad \text{.......... (4B)}$$

$$\frac{\partial^2 u^z}{\partial \rho^2} + \frac{1}{\rho}.\frac{\partial u^z}{\partial \rho} + \frac{\partial^2 u^z}{\partial z^2} = \frac{1}{c^2}.\frac{\partial^2 u^z}{\partial t^2} \qquad \text{................ (4C)}$$

Symmetric solutions of the above equations (4) can now be easily obtained as functions of space-time coordinates, that satisfy the essential conditions of vanishing of displacement vector components (u^ρ, u^ϕ, u^z) at the boundary and time invariance of the strain energy density within the boundary.

3. THE NUCLEON CORE.

3.1 <u>Displacement Vector Field.</u> One most important, lowest order, symmetric solution of equilibrium equations (4), that will represent the nucleon core, is

$$u^\rho = A_n.e\kappa.\ J_1(x).\ Cos(qz).\ Cos(\kappa ct)\ ; \qquad \text{.............. (5A)}$$

$$u^\phi = A_n.e\kappa.\ J_1(x).\ Cos(qz).\ Sin(\kappa ct)\ ;\ \ \& \qquad u^z = 0 \qquad \text{.................. (5B)}$$

where A_n is a dimensionless number, $x = (\kappa^2 - q^2)^{1/2}\rho$ and let $y = qz$. Here x and y are not the Cartesian coordinates but dimensionless parameters. The boundary surface Σ is given by $-\pi/2 \le qz \le \pi/2$ & $0 \le x \le \alpha_1$ with $J_1(\alpha_1) = 0$ or $\alpha_1=3.832$. Here 'e' is the magnitude of electron charge; κ is the wave number of strain wave oscillations and separately determined from the electron structure[2] to be equal to 1.73767×10^{15} m^{-1}. The strain wave oscillation frequency $\nu_e = \kappa.c/2\pi$ is required to be the same for all mutually interacting particles, like the electron, positron, nucleon and the mesons.

3.2 <u>The Strain Components.</u> Various strain components for the nucleon core defined by equations (5) can now be obtained by using equations (3) as given below

$$S^\rho_\rho(n) = A_n.e\kappa\sqrt{\kappa^2 - q^2}.J_1'(x).Cos(qz).Cos(\kappa ct)$$

$$S^\rho_\phi(n) = -A_n.e\kappa\sqrt{\kappa^2 - q^2}.\frac{J_1(x)}{x}.Cos(qz).Sin(\kappa ct)$$

$$S^\rho_z(n) = -A_n.e\kappa q.J_1(x).Sin(qz).Cos(\kappa ct)$$

$$S^\rho_t(n) = -A_n.e\kappa^2.J_1(x).Cos(qz).Sin(\kappa ct)$$

$$S^\phi_\rho(n) = A_n.e\kappa\sqrt{\kappa^2 - q^2}.J_1'(x).Cos(qz).Sin(\kappa ct)$$

$$S^\phi_\phi(n) = A_n.e\kappa\sqrt{\kappa^2 - q^2}.\frac{J_1(x)}{x}.Cos(qz).Cos(\kappa ct)$$

$$S_z^{\phi}(n) = -A_n . e\kappa q . J_1(x) . \mathrm{Sin}(qz) . \mathrm{Sin}(\kappa ct)$$

$$S_t^{\phi}(n) = A_n . e\kappa^2 . J_1(x) . \mathrm{Cos}(qz) . \mathrm{Cos}(\kappa ct) \qquad \text{............(6)}$$

$$\text{where} \quad J_1^{'}(x) = J_0(x) - \frac{J_1(x)}{x}$$

These strain components of the strain bubble representing a nucleon core, are sinusoidal in time t as well as axial distance z.

3.3 <u>Strain Energy Content.</u> The strain energy density in the nucleon core is given by the relation

$$W_n = \frac{1}{2\varepsilon_0}\left[\text{Sum of the squares of all strain components}\right] \qquad \text{................(7)}$$

That is, from equations (6) when we take pair wise sum of the squares of all strain components, Sin(κct) and Cos(κct) terms vanish and we get

$$W_n = \frac{A_n^2 e^2 \kappa^2}{2\varepsilon_0}\left[\left(\kappa^2 - q^2\right)\left\{\left(J_1^{'}(x)\right)^2 + \frac{J_1^2(x)}{x^2}\right\}\mathrm{Cos}^2(qz) + J_1^2(x)\left\{\kappa^2 \mathrm{Cos}^2(qz) + q^2 \mathrm{Sin}^2(qz)\right\}\right]$$

This is a unique feature of the strain bubble representing a nucleon core that the strain energy density within the core region is completely time invariant implying overall stability of the nucleon. Total strain energy content within the nucleon core can now be computed by integrating W_n over the entire volume of the core. If $2z_1$ is the axial length and ρ_1 is the boundary radius of the core such that $z_1 = \pi/2q$ and $\rho_1 = \alpha_1/(\kappa^2 - q^2)^{1/2}$; then the total energy content E_n will be given by

$$E_n = \int_0^{2\pi}\int_{-z_1}^{z_1}\int_0^{\rho_1} W_n . \rho . d\rho . dz . d\Phi = \frac{4\pi}{\left(\kappa^2 - q^2\right)} . \int_0^{z_1}\int_0^{\alpha_1} W_n . x . dx . dz$$

After substituting the values of W_n and z_1 in the above integral and further evaluation we get

$$E_n = \frac{\pi^2 A_n^2 e^2 \kappa \alpha_1^2 J_0^2(\alpha_1)}{2\varepsilon_0 (q/\kappa)\left(1 - (q/\kappa)^2\right)} \qquad \text{..........................(8A)}$$

This total strain energy function will get minimized for $q/\kappa = 1/\sqrt{3}$. On substituting this value q/κ in the above equations (5), (6) & (8A), we finally get

$$E_n = \frac{3\sqrt{3}\pi^2 A_n^2 e^2 \kappa \alpha_1^2 J_0^2(\alpha_1)}{4\varepsilon_0} \quad \text{Joule} \qquad \text{........................(8B)}$$

Substituting the values of various parameters in the above equation and converting energy units from Joule to MeV, we get $E_n = 960.1836 A_n^2$ MeV. Comparing this value of total strain energy contained in the nucleon core with the known mass energy of the neutron (**m_n**=939.576 MeV), the dimensionless constant A_n is found to be $A_n = 0.9892$

3.4 Size of the Nucleon Core. The overall size of the nucleon core can now be established by substituting the value of $q = \kappa/\sqrt{3}$; $\kappa = 1.73767\times10^{15}\ m^{-1}$; α_1=3.832 in the relations $z_1 = \pi/2q$ & $\rho_1 = \alpha_1/(\kappa^2 - q^2)^{1/2}$. Thus we find the maximum length of the nucleon core to be $= 2z_1 = 3.1314$ f . Maximum radius of the nucleon core is found to be $= \rho_1 = 2.7$ f . Hence we find that the nucleon core is of the shape of a right circular cylinder of diameter 5.4 f and length 3.1314 f .

3.5 Intrinsic Spin Concept. It can be easily seen from phase quadrature of displacement components u^ρ & u^ϕ that the resultant displacement vector in any transverse plane keeps continuously rotating or 'spinning' with constant angular velocity $\omega = \kappa c$ whereas its magnitude remains constant or time invariant at any space point. Direction of this 'spin' of the displacement vector is obviously along the axis of the strain bubble and remains constant with time. This constant 'intrinsic spin' of the displacement vector **U** in the nucleon core may be, at least partly, identified with the conventional notion of 'Spin' in these particles. Another part of the nucleon spin could be associated with the mechanical rotation of the core about Z-axis, for which its moment of inertia works out to be equal to $I_n = 4.6259\times10^{-57}$ kg.m^2 . However, as we shall see later, still another part of the nucleon spin and the anomalous magnetic moment could be associated with the orbital motion of the positron and the electron within the nucleon core.

4. STRONG INTERACTIONS

4.1 Nature of Strong Interactions. If the strain fields of two strain bubbles overlap in a certain region, the total strain components will be obtained by superposing corresponding components of both the strain bubbles referred to a common coordinate system, resulting in strain bubble interactions. When the cores of two or more interacting strain bubbles get partly overlapped, the resulting interaction is the 'strong interaction' encountered among nucleons and many other elementary particles. Interaction energy (E_{int}) of two such interacting strain bubbles may be defined as the difference between the total strain energy of the two strain bubbles with superposed strain fields (E_{sup}) and the sum of separate strain field energies of two bubbles (E_1 and E_2).

$$E_{int} = E_{sup} - (E_1 + E_2) \qquad \text{.............................. (9)}$$

If $S^i_j(1)$ and $S^i_j(2)$ represent the strain components of bubbles 1 and 2, referred to the same coordinate system then it can be seen from equations (7) that the interaction energy density W_{int} will be given by the sum of products of the corresponding strain components

$$W_{int}(1,2) = (1/2\varepsilon_0).\Sigma[\{ S^i_j(1) + S^i_j(2) \}^2 - \{ S^i_j(1) \}^2 - \{ S^i_j(2) \}^2]$$
$$= (1/\varepsilon_0).\ \Sigma[S^i_j(1).\ S^i_j(2)] \qquad (i \rightarrow 1 \text{ to } 3\ \&\ j \rightarrow 1 \text{ to } 4) \qquad \text{.............(10)}$$

5. AXIAL n-n STRONG INTERACTION

5.1 Let us consider a nucleon core centered at the origin 'O' of a cylindrical coordinate system (y^i), defined by $y^1=\rho$, $y^2=\phi$, $y^3=z$. Let the core axis be aligned along the

Z-axis (Figure 1). From equations (5), the non-zero displacement components for this nucleon core termed (O) will be given by,

$$u^{\rho}(O) = A_n.e\kappa.\ J_1(x).\ Cos(y).\ Cos(\kappa ct) \quad \ldots\ldots\ldots\ldots\ldots \text{(11A)}$$

$$u^{\phi}(O) = A_n.e\kappa.\ J_1(x).\ Cos(y).\ Sin(\kappa ct) \quad \ldots\ldots\ldots\ldots\ldots \text{(11B)}$$

where $x = \sqrt{2/3}(\kappa\rho)$; $y = \sqrt{1/3}(\kappa z)$ with $0 \le x \le \alpha_1$ and $-\pi/2 \le y \le \pi/2$.
The corresponding strain components for this nucleon core are,

$$S_{\rho}^{\rho}(O) = \sqrt{2/3}.A_n.e\kappa^2.J_1^{'}(x).Cos(y).Cos(\kappa ct)$$

$$S_{\phi}^{\rho}(O) = -\sqrt{2/3}.A_n.e\kappa^2.\frac{J_1(x)}{x}.Cos(y).Sin(\kappa ct)$$

$$S_{z}^{\rho}(O) = -\sqrt{1/3}.A_n.e\kappa^2.J_1(x).Sin(y).Cos(\kappa ct)$$

$$S_{t}^{\rho}(O) = -A_n.e\kappa^2.J_1(x).Cos(y).Sin(\kappa ct)$$

$$S_{\rho}^{\phi}(O) = \sqrt{2/3}.A_n.e\kappa^2.J_1^{'}(x).Cos(y).Sin(\kappa ct)$$

$$S_{\phi}^{\phi}(O) = \sqrt{2/3}.A_n.e\kappa^2.\frac{J_1(x)}{x}.Cos(y).Cos(\kappa ct)$$

$$S_{z}^{\phi}(O) = -\sqrt{1/3}.A_n.e\kappa^2.J_1(x).Sin(y).Sin(\kappa ct)$$

$$S_{t}^{\phi}(O) = A_n.e\kappa^2.J_1(x).Cos(y).Cos(\kappa ct) \quad \ldots\ldots\ldots\ldots\text{(12)}$$

5.2 Let us now consider the second nucleon core centered at point 'A' on the z-axis at distance L from the origin (Fig.1), such that its intrinsic spin direction is parallel to that of first core (O). Further let the displacement vector and strain components of nucleon core (A) be referred to a local cylindrical coordinate system ρ, ϕ, Z such that Z= z-L . Therefore the displacement components for this nucleon core termed (A) will be given by,

$$u^{\rho}(A) = A_n.e\kappa.\ J_1(x).\ Cos(Y).\ Cos(\kappa ct) \quad \ldots\ldots\ldots\ldots\ldots \text{(13A)}$$

$$u^{\phi}(A) = A_n.e\kappa.\ J_1(x).\ Cos(Y).\ Sin(\kappa ct) \quad \ldots\ldots\ldots\ldots\ldots \text{(13B)}$$

where $x = \sqrt{2/3}(\kappa\rho)$; $Y = \sqrt{1/3}(\kappa Z) = y - \kappa L/\sqrt{3}$; with $0 \le x \le \alpha_1$ and $-\pi/2 \le Y \le \pi/2$.
Further, let $\delta = L/z_1 = (2\kappa L)/(\pi\sqrt{3})$ so that $Y = y - \delta(\pi/2)$. Corresponding strain components for the nucleon core (A) referred to coordinate system ρ, ϕ, z are,

$$S_{\rho}^{\rho}(A) = \sqrt{2/3}.A_n.e\kappa^2.J_1^{'}(x).Cos(Y).Cos(\kappa ct)$$

$$S_{\phi}^{\rho}(A) = -\sqrt{\frac{2}{3}}.A_n.e\kappa^2.\frac{J_1(x)}{x}.Cos(Y).Sin(\kappa ct)$$

$$S_{z}^{\rho}(A) = -\sqrt{1/3}.A_n.e\kappa^2.J_1(x).Sin(Y).Cos(\kappa ct)$$

$$S_t^{\rho}(A) = -A_n.e\kappa^2.J_1(x).Cos(Y).Sin(\kappa ct)$$

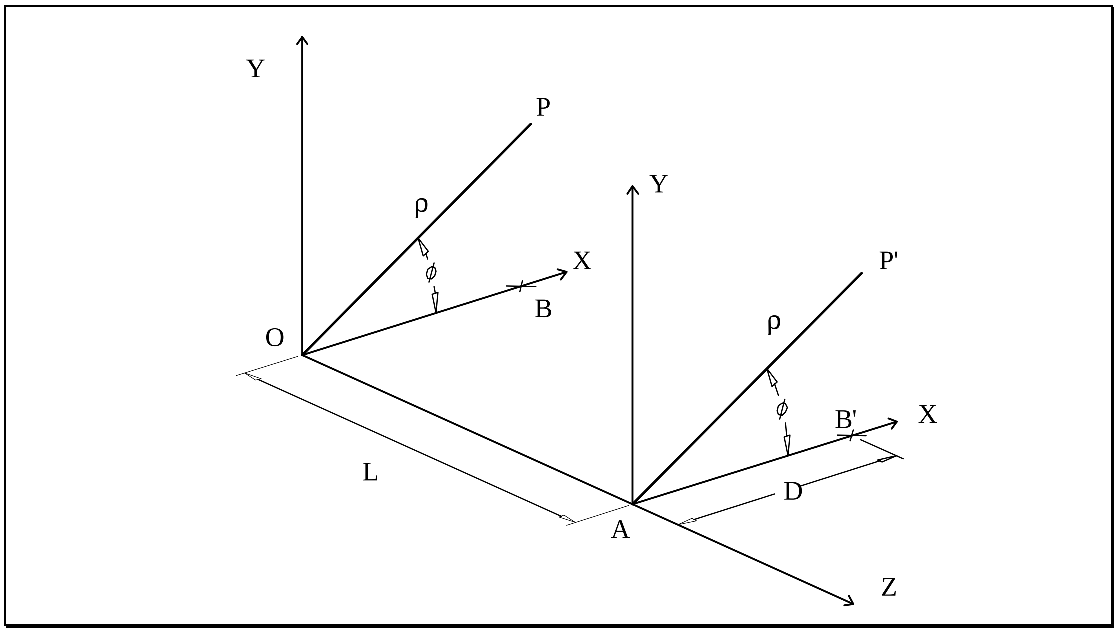
$$S_\rho^{\phi}(A) = \sqrt{2/3}.A_n.e\kappa^2.J_1^{'}(x).Cos(Y).Sin(\kappa ct)$$

$$S_\phi^{\phi}(A) = \sqrt{\frac{2}{3}}A_n.e\kappa^2.\frac{J_1(x)}{x}.Cos(Y).Cos(\kappa ct)$$

$$S_z^{\phi}(A) = -\sqrt{1/3}.A_n.e\kappa^2.J_1(x).Sin(Y).Sin(\kappa ct)$$

$$S_t^{\phi}(A) = A_n.e\kappa^2.J_1(x).Cos(Y).Cos(\kappa ct) \qquad ....(14)$$

Figure 1



5.3 We know from equation (10), that the axial interaction energy density W_{ina} in the common overlap region of the two cores will be given by ($1/\varepsilon_0$) times the sum of products of the corresponding strain components. Therefore, after pair wise summation of the required products from equations (12) and (14), we get

$$W_{ina}(n,n) = \frac{A_n^2.e^2\kappa^4}{\varepsilon_0}.\begin{bmatrix} Cos(y)Cos(Y).\left\{\frac{2}{3}.\left(\left(J_1^{'}(x)\right)^2 + \frac{J_1^2(x)}{x^2}\right) + J_1^2(x)\right\} \\ + Sin(y)Sin(Y).\left\{\frac{1}{3}.J_1^2(x)\right\} \end{bmatrix}$$

Using the relations- $Cos(y)Cos(Y) = (1/2).\{Cos(2y - \delta\pi/2) + Cos(\delta\pi/2)\}$

and $Sin(y)Sin(Y) = (1/2).\{Cos(\delta\pi/2) - Cos(2y - \delta\pi/2)\}$

The strain energy density function simplifies to

$$W_{ina}(n,n) = \frac{A_n^2.e^2\kappa^4}{3\varepsilon_0}.\left[\begin{array}{l} \mathrm{Cos}(\delta\pi/2).\left\{\left(\left(J_1^{'}(x)\right)^2 + \dfrac{J_1^2(x)}{x^2}\right) + 2J_1^2(x)\right\} \\ + \mathrm{Cos}(2y - \delta\pi/2).\left\{\left(\left(J_1^{'}(x)\right)^2 + \dfrac{J_1^2(x)}{x^2}\right) + J_1^2(x)\right\} \end{array}\right] \quad \text{..........(15)}$$

5.4 The total axial interaction energy of two nucleon cores is obtained by integrating this energy density over the entire common overlap region, as

$$E_{ina}(n,n) = \int_0^{2\pi}\int_0^{\rho_1}\int_{L-z_1}^{z_1} W_{ina}.dz.\rho.d\rho.d\phi = \frac{6\pi\sqrt{3}}{\kappa^3}.\int_0^{\alpha_1}\int_{\delta\pi/4}^{\pi/2} W_{ina}.x.dx.dy$$

$$= \frac{\pi\sqrt{3}A_n^2.e^2\kappa.\alpha_1^2.J_0^2(\alpha_1)}{\varepsilon_0}.\left[\frac{3\pi}{2}.\left(1-\frac{\delta}{2}\right).\mathrm{Cos}(\delta\pi/2) + \mathrm{Sin}(\delta\pi/2)\right] \quad \text{...............(16)}$$

The total axial interaction energy E_{ina} can be written as a fraction of E_n by using (8B), as

$$E_{ina}(n,n) = \left[(2-\delta).\mathrm{Cos}(\delta\pi/2) + (4/3\pi).\mathrm{Sin}(\delta\pi/2)\right].E_n$$

$$= \left[(2-\delta).\mathrm{Cos}(\delta\pi/2) + (4/3\pi).\mathrm{Sin}(\delta\pi/2)\right] \times 939.576 \quad \text{Mev} \quad \text{.............. (17)}$$

Figure 2a

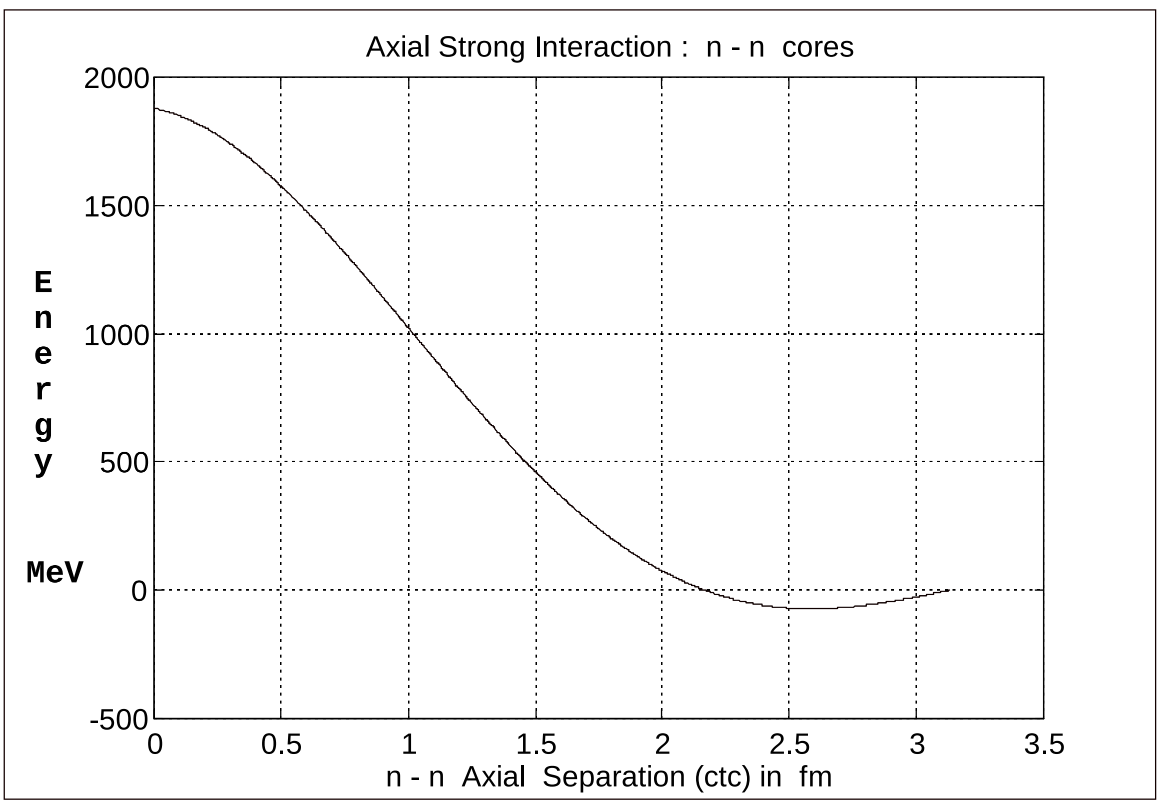
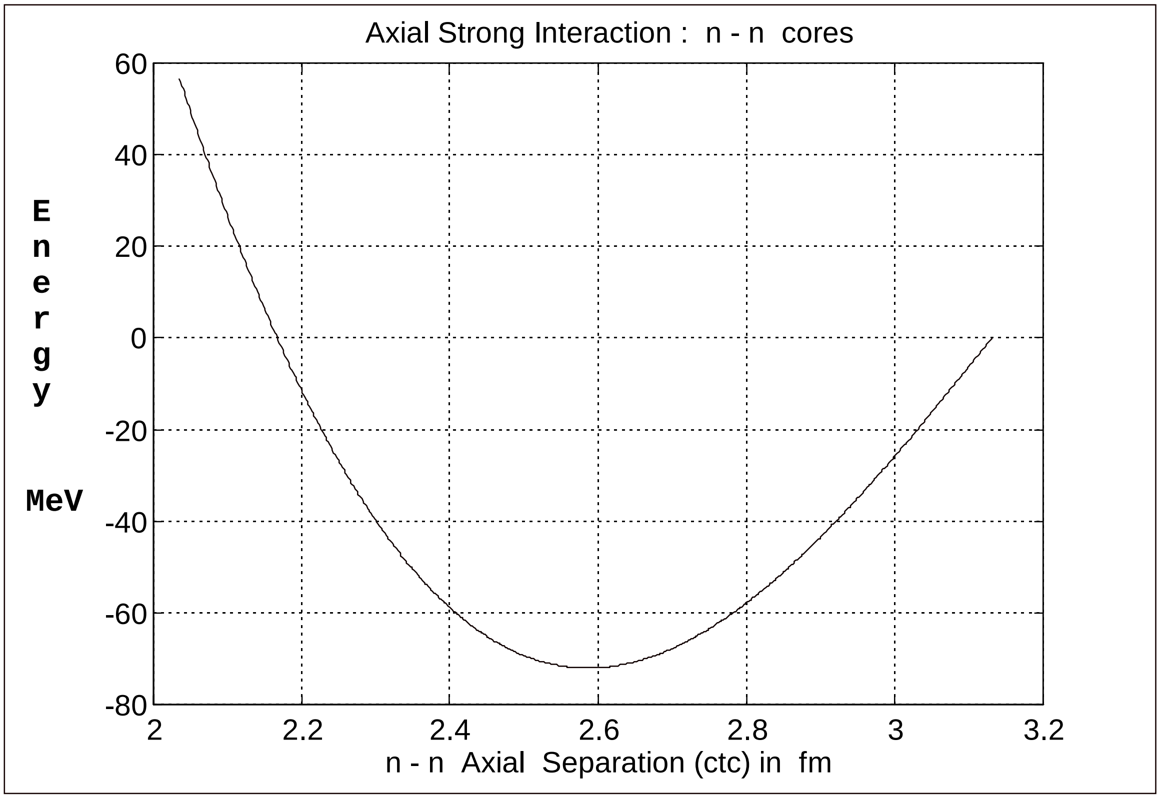


Figure 2b

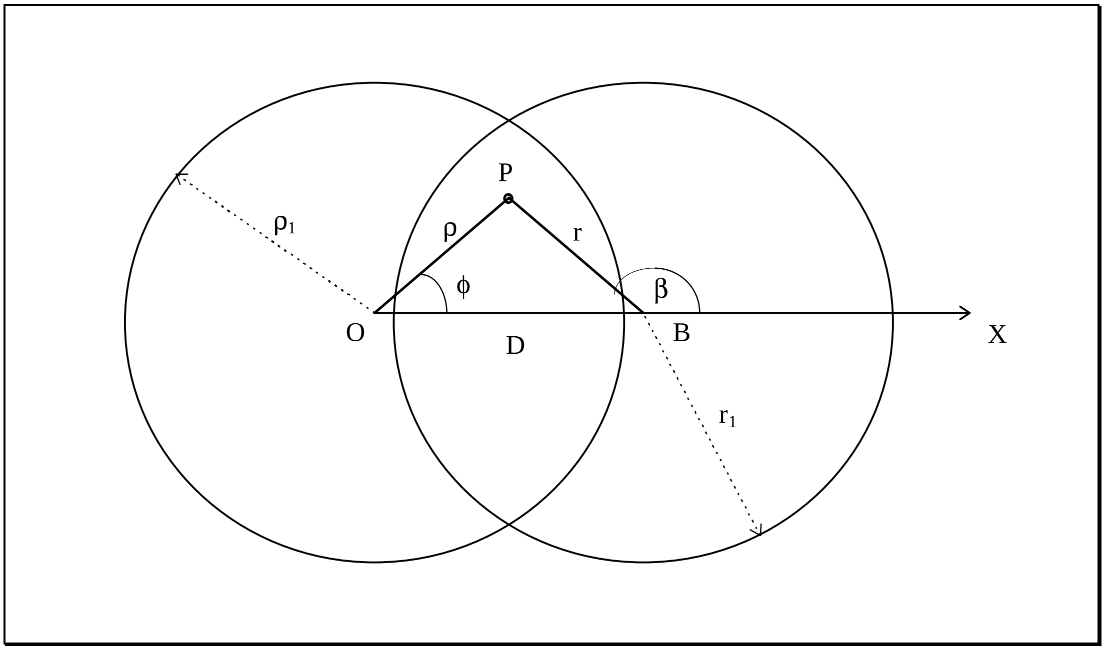


Equation (17) gives the axial interaction energy in MeV, as a function of axial separation $\delta=L/z_1$ between the two interacting nucleons. This energy is zero at $\delta=2$ when the nucleons are fully separated and increases to $2E_n$ for $\delta=0$ when the nucleons are fully superposed. For $1.834< \delta < 2$ the interaction energy is negative. The exact variation of E_{ina} with δ is shown in figures 2a & 2b. The negative energy part of this axial interaction is an important feature which enables axial bonding between a neutron and a proton. In this p-n coupling, mean separation between the centers of two cores is about 2.6 f, varying from about 2.1 f to 3.1 f and frequency of their axial oscillations is about 5.21×10^{22} Hz.

6. RADIAL n-n STRONG INTERACTION

6.1 Let us again consider a nucleon core centered at the origin 'O' of a cylindrical coordinate system (y^i), defined by $y^1=\rho$, $y^2=\phi$, $y^3=z$. Let the core axis be aligned along the Z-axis. The non-zero displacement components for this nucleon core termed (O) are given by equation (11) and the corresponding strain components by equation (12). Let us now consider another nucleon core with its axis parallel to the axis of core (O) but separated by distance D (Fig.3). Consider a point B in a radial direction $\phi=0$, such that OB=D. Axis of the second core termed core(B) will pass through point B. Further let the center of core B' be displaced from the plane z=0, along positive z-axis by distance L (Fig.1). Let the core(B) be referred to a local coordinate system (x^i) defined by $x^1=r$, $x^2=\beta$, $x^3=Z$ such that $Z=z-L$. Maximum radii of both cores are $\rho_1=r_1$. Further let $D/\rho_1 = \eta$; $L/z_1 = \delta$; $x=\sqrt{2/3}.\kappa\rho$; $X =\sqrt{2/3}.\kappa r$; $y = \sqrt{1/3}.\kappa z$; $Y = \sqrt{1/3}.\kappa Z = y - \sqrt{1/3}.\kappa d = y - \delta(\pi/2)$.

Figure 3



6.2 The coordinates of any point P located in a common overlap region of two cores, referred to the coordinate systems y^i and x^i will be inter-related through following transformation relations:

$$\rho\,\mathrm{Sin}(\phi) = r\,\mathrm{Sin}(\beta)\;; \qquad \rho\,\mathrm{Cos}(\phi) - D = r\,\mathrm{Cos}(\beta)\;;$$

$$\rho^2 = r^2 + D^2 + 2rD\,\mathrm{Cos}(\beta)\;; \qquad r^2 = \rho^2 + D^2 - 2\rho D\,\mathrm{Cos}(\phi)\;;$$

$$\&\quad \chi = \sqrt{x^2 + \eta^2\alpha_1^2 - 2x\eta\alpha_1\mathrm{Cos}(\phi)} \qquad \text{where}\quad \chi = \sqrt{2/3}(\kappa r) \qquad \text{...........}\ (18)$$

From the above relations, the coordinate transformation Jacobian Matrices of their partial derivatives are obtained as

$$\frac{\partial y^1}{\partial x^1} = \frac{\partial \rho}{\partial r} = \frac{\rho - D.\cos\phi}{r}\;; \qquad \frac{\partial y^1}{\partial x^2} = \frac{\partial \rho}{\partial \beta} = -D.\sin\phi\;; \qquad \frac{\partial y^1}{\partial x^3} = \frac{\partial \rho}{\partial Z} = 0$$

$$\frac{\partial y^2}{\partial x^1} = \frac{\partial \phi}{\partial r} = \frac{D.\sin\phi}{r.\rho}\;; \qquad \frac{\partial y^2}{\partial x^2} = \frac{\partial \phi}{\partial \beta} = \frac{\rho - D.\cos\phi}{\rho}\;; \qquad \frac{\partial y^2}{\partial x^3} = \frac{\partial \phi}{\partial Z} = 0$$

$$\frac{\partial y^3}{\partial x^1} = \frac{\partial z}{\partial r} = 0\;; \qquad \frac{\partial y^3}{\partial x^2} = \frac{\partial z}{\partial \beta} = 0\;; \qquad \frac{\partial y^3}{\partial x^3} = \frac{\partial z}{\partial Z} = 1 \qquad \text{.......}(19)$$

And
$$\frac{\partial x^1}{\partial y^1} = \frac{\partial r}{\partial \rho} = \frac{\rho - D.\cos\phi}{r}\;; \qquad \frac{\partial x^1}{\partial y^2} = \frac{\partial r}{\partial \phi} = \frac{\rho.D.\sin\phi}{r}\;; \qquad \frac{\partial x^1}{\partial y^3} = \frac{\partial r}{\partial z} = 0$$

$$\frac{\partial x^2}{\partial y^1} = \frac{\partial \beta}{\partial \rho} = \frac{-D.\sin\phi}{r^2}\;; \qquad \frac{\partial x^2}{\partial y^2} = \frac{\partial \beta}{\partial \phi} = \frac{\rho.(\rho - D.\cos\phi)}{r^2}\;; \qquad \frac{\partial x^2}{\partial y^3} = \frac{\partial \beta}{\partial z} = 0$$

$$\frac{\partial x^3}{\partial y^1} = \frac{\partial Z}{\partial \rho} = 0 \quad ; \quad \frac{\partial x^3}{\partial y^2} = \frac{\partial Z}{\partial \phi} = 0 \quad ; \quad \frac{\partial x^3}{\partial y^3} = \frac{\partial Z}{\partial z} = 1 \qquad \ldots\ldots.(20)$$

6.3 The displacement components for the second nucleon core termed (B) and referred to coordinate system x^i (r, β, Z) are therefore given by,

$u^r(B) = A_n.e\kappa.\ J_1(\chi).\ Cos(Y).\ Cos(\kappa ct)$ ………….. (21A)

$u^\beta(B) = A_n.e\kappa.\ J_1(\chi).\ Cos(Y).\ Sin(\kappa ct)$ ………….. (21B)

where $\chi = \sqrt{2/3}(\kappa r)$; $Y = \sqrt{1/3}(\kappa Z)$ = y - δ(π/2); with $0 \le \chi \le \alpha_1$ and $-\pi/2 \le Y \le \pi/2$.
Corresponding strain components for the core (B) referred to coordinate system r, β, Z are,

$$\varepsilon^r_r(B) = \sqrt{2/3}.A_n.e\kappa^2.J_1'(\chi).Cos(Y).Cos(\kappa ct)$$

$$\varepsilon^r_\beta(B) = -\sqrt{\frac{2}{3}}.A_n.e\kappa^2.\frac{J_1(\chi)}{\chi}.Cos(Y).Sin(\kappa ct)$$

$$\varepsilon^r_Z(B) = -\sqrt{1/3}.A_n.e\kappa^2.J_1(\chi).Sin(Y).Cos(\kappa ct)$$

$$\varepsilon^r_t(B) = -A_n.e\kappa^2.J_1(\chi).Cos(Y).Sin(\kappa ct)$$

$$\varepsilon^\beta_r(B) = \sqrt{2/3}.A_n.e\kappa^2.J_1'(\chi).Cos(Y).Sin(\kappa ct)$$

$$\varepsilon^\beta_\beta(B) = \sqrt{\frac{2}{3}}A_n.e\kappa^2.\frac{J_1(\chi)}{\chi}.Cos(Y).Cos(\kappa ct)$$

$$\varepsilon^\beta_Z(B) = -\sqrt{1/3}.A_n.e\kappa^2.J_1(\chi).Sin(Y).Sin(\kappa ct)$$

$$\varepsilon^\beta_t(B) = A_n.e\kappa^2.J_1(\chi).Cos(Y).Cos(\kappa ct) \qquad \ldots\ldots\ldots\ldots(22)$$

Now these strain components have to be transformed to coordinate system y^i(ρ, ϕ, z) centered at O by using the relations,

$$S^i_j(B) = \frac{\partial y^i}{\partial x^\alpha}.\varepsilon^\alpha_\beta(B).\frac{\partial x^\beta}{\partial y^j} \qquad \text{(summation over } \alpha \text{ and } \beta) \qquad \ldots\ldots.(23)$$

However, before carrying out this transformation we have to first convert the physical strain components $\varepsilon^{x^i}_{x^j}(B)$ given by equations (22), to the corresponding strain tensor components $\varepsilon^i_j(B)$ through the relation,

$$\varepsilon^{x^i}_{x^j}(B) = \sqrt{g_{ii}}.\varepsilon^i_j(B).\sqrt{g^{jj}} \qquad \text{(no summation over i or j)} \qquad \ldots\ldots\ldots.(24)$$

And again after using equation (23) the strain tensor components $S^i_j(B)$ will have to be converted back to the physical components $S^{y^i}_{y^j}(B)$ using the above relation.

6.4 Finally the strain components (22) due to the nucleon core (B), when properly transformed by using equations (19), (20), (23) and (24) to the cylindrical coordinate system y^i (ρ, ϕ, z) centered at O, are obtained as,

$$S_\rho^\rho(B) = \sqrt{\frac{2}{3}} A_n e\kappa^2 \mathrm{Cos}(Y) \left[\begin{array}{l} \left\{ \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))^2}{\chi^2} J_1'(\chi) + \frac{\eta^2\alpha_1^2 \mathrm{Sin}^2(\phi)}{\chi^3} J_1(\chi) \right\} \mathrm{Cos}(\kappa ct) \\ + \left\{ \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi^2} \left(\frac{J_1(\chi)}{\chi} - J_1'(\chi) \right) \right\} \mathrm{Sin}(\kappa ct) \end{array} \right]$$

$$S_\rho^\phi(B) = \sqrt{\frac{2}{3}} A_n e\kappa^2 \mathrm{Cos}(Y) \left[\begin{array}{l} \left\{ \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))^2}{\chi^2} J_1'(\chi) + \frac{\eta^2\alpha_1^2 \mathrm{Sin}^2(\phi)}{\chi^3} J_1(\chi) \right\} \mathrm{Sin}(\kappa ct) \\ - \left\{ \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi^2} \left(\frac{J_1(\chi)}{\chi} - J_1'(\chi) \right) \right\} \mathrm{Cos}(\kappa ct) \end{array} \right]$$

$$S_\phi^\rho(B) = -\sqrt{\frac{2}{3}} A_n e\kappa^2 \mathrm{Cos}(Y) \left[\begin{array}{l} \left\{ \frac{\eta^2\alpha_1^2 \mathrm{Sin}^2(\phi)}{\chi^2} J_1'(\chi) + \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))^2}{\chi^3} J_1(\chi) \right\} \mathrm{Sin}(\kappa ct) \\ + \left\{ \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi^2} \left(\frac{J_1(\chi)}{\chi} - J_1'(\chi) \right) \right\} \mathrm{Cos}(\kappa ct) \end{array} \right]$$

$$S_\phi^\phi(B) = \sqrt{\frac{2}{3}} A_n e\kappa^2 \mathrm{Cos}(Y) \left[\begin{array}{l} \left\{ \frac{\eta^2\alpha_1^2 \mathrm{Sin}^2(\phi)}{\chi^2} J_1'(\chi) + \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))^2}{\chi^3} J_1(\chi) \right\} \mathrm{Cos}(\kappa ct) \\ - \left\{ \frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi^2} \left(\frac{J_1(\chi)}{\chi} - J_1'(\chi) \right) \right\} \mathrm{Sin}(\kappa ct) \end{array} \right]$$

$$S_z^\rho(B) = -\sqrt{\frac{1}{3}} A_n e\kappa^2 J_1(\chi) \mathrm{Sin}(Y) \left[\frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))}{\chi} \mathrm{Cos}(\kappa ct) - \frac{\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi} \mathrm{Sin}(\kappa ct) \right]$$

$$S_z^\phi(B) = -\sqrt{\frac{1}{3}} A_n e\kappa^2 J_1(\chi) \mathrm{Sin}(Y) \left[\frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))}{\chi} \mathrm{Sin}(\kappa ct) + \frac{\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi} \mathrm{Cos}(\kappa ct) \right]$$

$$S_t^\rho(B) = -A_n e\kappa^2 J_1(\chi) \mathrm{Cos}(Y) \left[\frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))}{\chi} \mathrm{Sin}(\kappa ct) + \frac{\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi} \mathrm{Cos}(\kappa ct) \right]$$

$$S_t^\phi(B) = A_n e\kappa^2 J_1(\chi) \mathrm{Cos}(Y) \left[\frac{(x-\eta\alpha_1 \mathrm{Cos}(\phi))}{\chi} \mathrm{Cos}(\kappa ct) - \frac{\eta\alpha_1 \mathrm{Sin}(\phi)}{\chi} \mathrm{Sin}(\kappa ct) \right] \quad ....(25)$$

6.5 From equation (10), interaction energy density is given by ($1/\varepsilon_0$) times the sum of products of the corresponding strain components. Therefore, for computing the radial interaction energy of two cores (O) and (B), we may first compute the sum of pairs of products of the corresponding strain components from equations (12) and (25) as follows.

$$\Sigma_\rho(n,n) = S_\rho^\rho(O).S_\rho^\rho(B) + S_\rho^\phi(O).S_\rho^\phi(B)$$

$$= \frac{2}{3} A_n^2 e^2 \kappa^4 J_1^{'}(x)\mathrm{Cos}(y)\mathrm{Cos}(Y)\left[\frac{\left(x - \eta\alpha_1 \mathrm{Cos}(\phi)\right)^2}{\chi^2} J_1^{'}(\chi) + \frac{\eta^2\alpha_1^2 \mathrm{Sin}^2(\phi)}{\chi^3} J_1(\chi)\right]$$

$$\Sigma_\phi(n,n) = S_\phi^\rho(O).S_\phi^\rho(B) + S_\phi^\phi(O).S_\phi^\phi(B)$$

$$= \frac{2}{3} A_n^2 e^2 \kappa^4 \frac{J_1(x)}{x} \mathrm{Cos}(y)\mathrm{Cos}(Y)\left[\frac{\eta^2\alpha_1^2 \mathrm{Sin}^2(\phi)}{\chi^2} J_1^{'}(\chi) + \frac{\left(x - \eta\alpha_1 \mathrm{Cos}(\phi)\right)^2}{\chi^3} J_1(\chi)\right]$$

$$\Sigma_z(n,n) = S_z^\rho(O).S_z^\rho(B) + S_z^\phi(O).S_z^\phi(B) = A_n^2 e^2 \kappa^4 J_1(x) J_1(\chi) \mathrm{Sin}(y)\mathrm{Sin}(Y)\frac{\left(x - \eta\alpha_1 \mathrm{Cos}(\phi)\right)}{3\chi}$$

$$\Sigma_t(n,n) = S_t^\rho(O).S_t^\rho(B) + S_t^\phi(O).S_t^\phi(B) = A_n^2 e^2 \kappa^4 J_1(x) J_1(\chi) \mathrm{Cos}(y)\mathrm{Cos}(Y)\frac{\left(x - \eta\alpha_1 \mathrm{Cos}(\phi)\right)}{\chi}$$

Hence, the interaction energy density in the common overlap region is,

$$W_{inr}(n,n) = (1/\varepsilon_0)[\Sigma_\rho(n,n) + \Sigma_\phi(n,n) + \Sigma_z(n,n) + \Sigma_t(n,n)] \qquad ....(26)$$

This energy density function is completely time invariant and is a function of independent parameters ρ, ϕ, z, δ and η . If the intrinsic spin direction of one of the cores is reversed the resulting interaction energy density will no longer be time invariant leading to overall instability of such interaction. Hence, all meaningful and stable strong interactions among nucleons occur with their intrinsic spin directions parallel. As usual the total interaction energy of the strong interaction considered above, will be obtained by integrating W_{inr} over the entire volume of the common overlapped region.

$$E_{inr}(n,n) = \iiint W_{inr}(n,n).\rho.d\rho.d\phi.dz \qquad ....(27)$$

6.6 The volume integral at equation (27) above, with variable limits of integration, can not be easily evaluated analytically and we must take recourse to computerized numerical integration. For any given set of separation parameters δ and η, a unique value of interaction energy will be obtained. If the radial separation parameter η is set to zero, X will reduce to x and the interaction energy obtained from equation (27) will reduce to axial interaction energy given by equation (17). If on the other hand δ is set to zero, Y will reduce to y and equation (27) will then provide pure radial interaction energy. The radial interaction energy between two nucleon cores thus obtained is plotted at figures 4a & 4b for $0 \le \eta \le 2$. This is an important plot which shows maximum negative interaction energy between two nucleons at radial separation of one core radius, that is about 2.7 f .

Figure 4a

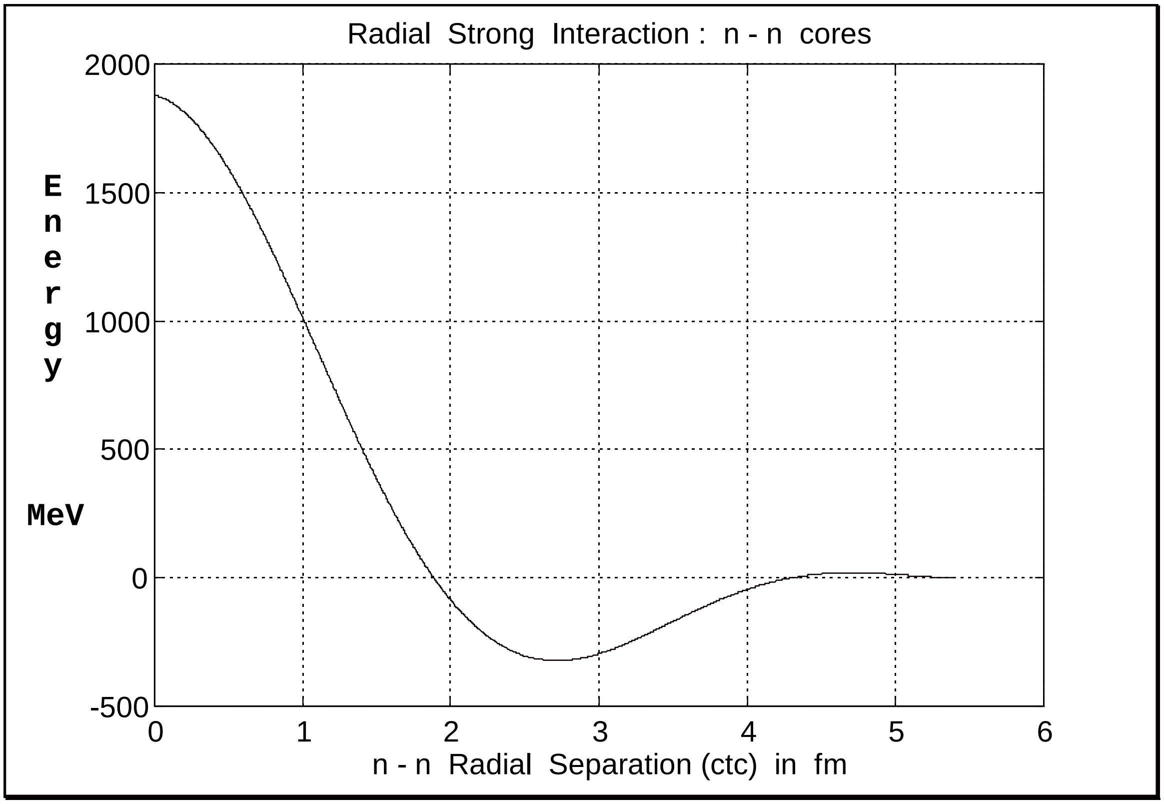
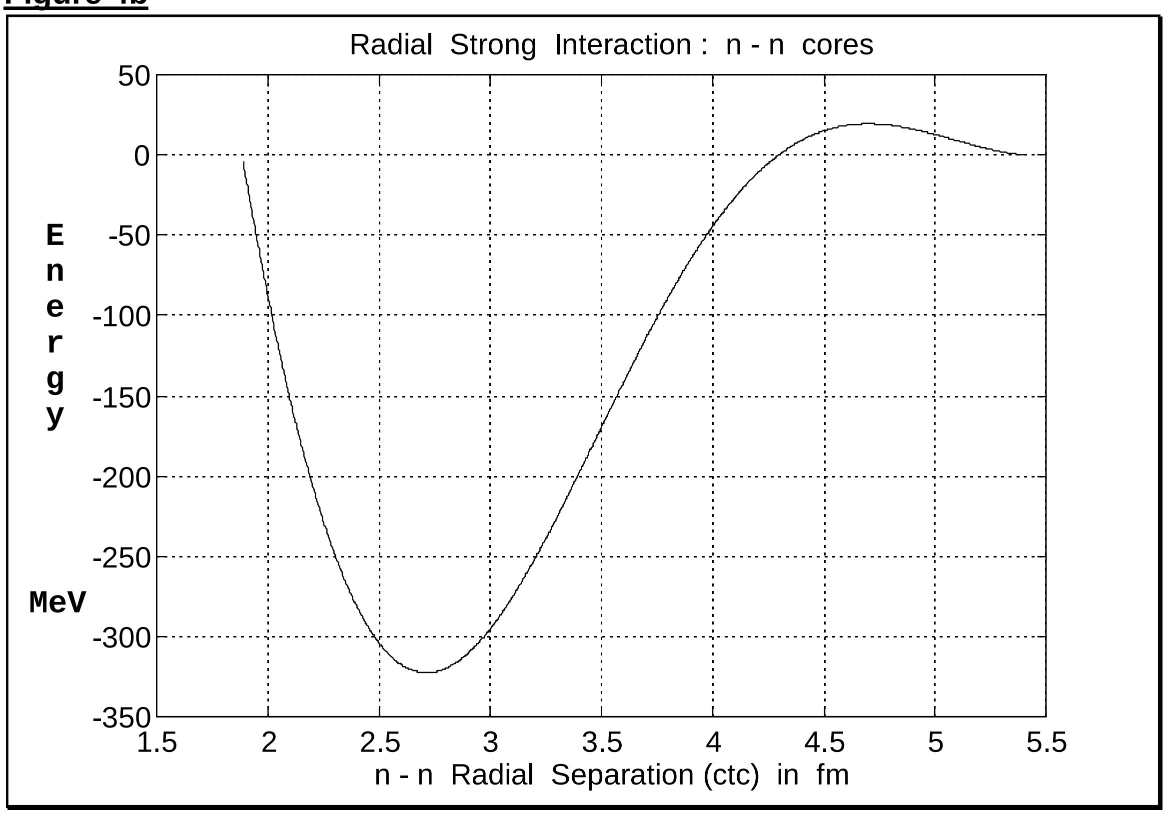


Figure 4b



6.7 It means that two nucleons are likely to get radially coupled together under suitable conditions and oscillate at a frequency of about 3.6×10^{22} Hz with mean radial separation of about 2.7 f . The radial interaction energy is positive for core separation between 0 to 1.9 f and again from about 4.3 f to the maximum limit of two core radii that is 5.4 f . The asymmetry of negative portion of this interaction energy curve with respect to its minima at 2.7 f , may lead to the rotational motion of the interacting nucleons alongside their above mentioned radial oscillations. The positive 'hump' of this interaction energy curve from 4.3 f to 5.4 f separation suggests that the radial coupling between two interacting nucleons may be very difficult to form and once formed may be much more difficult to break in comparison with their axial coupling.

6.8 However, the exact motion of interacting nucleons can not be studied in detail from the knowledge of interaction energy curve alone, without employing the techniques of 'revised' Quantum Mechanics. Furthermore, there is one very important point to be noted here regarding the magnitude of negative interaction energy available for strong coupling and the actual 'bond energy' ensuring stable binding between the interacting nucleons. The available interaction energy 'released' by the system, must be actually emitted out of the system for it to become 'bond energy' of the coupled nucleons. In practice only a small fraction of the negative interaction energy released by the system is actually emitted out of the system and the balance is converted to the kinetic energy of motion of the interacting nucleons. There must be a valid mechanism available for emitting a portion of the released interaction energy out of the system. The interacting nucleon cores by themselves do not appear to possess any such mechanism. Energy could be emitted out of the system with due conservation of energy and momentum, either as photons or some other elementary particles like mesons, neutrinos etc. But photons could be emitted out from the strain wave field region only through specific motion of charge particles - the electron and positron, whereas the neutrinos could be formed and emitted out from within the core region itself. Therefore the presence of positron and electron among the nucleons appears to be an essential feature in the coupling and securely binding the nucleons. Hence we next examine the strong interaction between the positron/electron cores and the nucleon core.

7. THE PROTON

7.1 The proton is known to be a positively charged nucleon. As per the ECT of the electron structure[2], the electron and positron are the only two stable charge particles consisting of a spherically symmetric oscillating strain wave core surrounded by radial propagating phase wave field type strain bubbles. As such it is quite reasonable to presume that the proton may consist of a nucleon core with a positron superposed over it through strong interaction. We may therefore, examine the strong interaction characteristics of the positron core with the nucleon core. In the foregoing, we have already examined the strong interaction characteristics of two nucleon cores. Proceeding on the same lines, let us replace the nucleon core centered at the origin O of the cylindrical coordinate system, with a positron core centered at the same point O.

7.2 The positron type strain bubbles are obtained as spherically symmetric lowest order solutions of equilibrium equations of elasticity in the Elastic Continuum[2]. Non-zero displacement vector components of the positron core, referred to a spherical coordinate system (R,θ, ϕ), with origin at O, are given by,

$u^R = A_e.e\kappa.G_1(X).\ Cos(\kappa ct);$ …………….. (28A)

$u^\phi = A_e.e\kappa.G_1(X).\ Sin(\theta).\ Sin(\kappa ct);$ …………….. (28B)

where $G_1(X) = (\cos X - \sin X / X)/X = -(\pi/2X)^{½}.\ J_{3/2}(X)$ and $X = \kappa R$;

The corresponding strain components for the positron core can be properly transformed to a cylindrical coordinate system (ρ, ϕ, z) with origin at point O, by the usual procedure discussed above. These strain components for the positron (e^+) core centered at point O, after proper transformation to the cylindrical coordinate system y^i (ρ, ϕ, z) are,

$$S^\rho_\rho(e^+) = \frac{A_e e\kappa^2}{X^2}\left[\frac{3}{2}x^2G_1^{'}(X) + 3y^2\frac{G_1(X)}{X}\right].Cos(\kappa ct)$$

$$S^\phi_\rho(e^+) = \frac{A_e e\kappa^2}{X^2}\left[\frac{3}{2}x^2G_1^{'}(X) + 3y^2\frac{G_1(X)}{X}\right].Sin(\kappa ct)$$

$$S^\rho_\phi(e^+) = -A_e e\kappa^2\left[\frac{G_1(X)}{X}\right].Sin(\kappa ct)$$

$$S^\phi_\phi(e^+) = A_e e\kappa^2\left[\frac{G_1(X)}{X}\right].Cos(\kappa ct)$$

$$S^\rho_z(e^+) = \frac{3A_e e\kappa^2 xy}{\sqrt{2}.X^2}.\left[G_1^{'}(X) - \frac{G_1(X)}{X}\right].Cos(\kappa ct)$$

$$S^\phi_z(e^+) = \frac{3A_e e\kappa^2 xy}{\sqrt{2}.X^2}.\left[G_1^{'}(X) - \frac{G_1(X)}{X}\right].Sin(\kappa ct)$$

$$S^\rho_t(e^+) = -A_e e\kappa^2.\sqrt{\frac{3}{2}}.x.\left[\frac{G_1(X)}{X}\right].Sin(\kappa ct)$$

$$S^\phi_t(e^+) = A_e e\kappa^2.\sqrt{\frac{3}{2}}.x.\left[\frac{G_1(X)}{X}\right].Cos(\kappa ct)$$

$$S^z_\rho(e^+) = \frac{3A_e e\kappa^2 xy}{\sqrt{2}.X^2}.\left[G_1^{'}(X) - \frac{G_1(X)}{X}\right].Cos(\kappa ct) \quad ; \qquad S^z_\phi(e^+) = 0$$

$$S^z_z(e^+) = \frac{A_e e\kappa^2}{X^2}.\left[3y^2G_1^{'}(X) + \frac{3}{2}x^2\frac{G_1(X)}{X}\right].Cos(\kappa ct)$$

$$S^z_t(e^+) = -\sqrt{3}A_e e\kappa^2 y.\left[\frac{G_1(X)}{X}\right].Sin(\kappa ct) \qquad ....(29)$$

Where, $R=\sqrt{(\rho^2+z^2)}$; $X = \kappa R = \kappa.\sqrt{(\rho^2+z^2)} = \sqrt{((3/2)x^2+3y^2)}$

with $x = \sqrt{(2/3)}.\kappa\rho$ and $y = \sqrt{(1/3)}.\kappa z$

7.3 From equation (10), interaction energy density in the common overlapped region of the interacting cores is given by ($1/\varepsilon_0$) times the sum of products of the corresponding strain components. Therefore, for computing the interaction energy of the positron (e^+) centered at O and the nucleon core (n) located at B, with their intrinsic spins parallel and axes separated by distance $D= \eta\rho_1$, we may first compute the sum of pairs of products of the corresponding strain components from equations (29) and (25) as follows.

$$\Sigma_\rho(e^+,n) = S^\rho_\rho(e^+).S^\rho_\rho(n)+S^\phi_\rho(e^+).S^\phi_\rho(n)$$
$$=\sqrt{\frac{2}{3}}\frac{A_eA_ne^2\kappa^4\text{Cos}(Y)}{X^2}\left\{\frac{3x^2}{2}G_1'(X)+3y^2\frac{G_1(X)}{X}\right\}\left[\frac{(x-\eta\alpha_1\text{Cos}(\phi))^2}{\chi^2}J_1'(\chi)+\frac{\eta^2\alpha_1^2\text{Sin}^2(\phi)}{\chi^3}J_1(\chi)\right]$$

$$\Sigma_\phi(e^+,n) = S^\rho_\phi(e^+).S^\rho_\phi(n)+S^\phi_\phi(e^+).S^\phi_\phi(n)$$
$$=\sqrt{\frac{2}{3}}A_eA_ne^2\kappa^4\text{Cos}(Y)\left\{\frac{G_1(X)}{X}\right\}\left[\frac{(x-\eta\alpha_1\text{Cos}(\phi))^2}{\chi^3}J_1(\chi)+\frac{\eta^2\alpha_1^2\text{Sin}^2(\phi)}{\chi^2}J_1'(\chi)\right]$$

$$\Sigma_z(e^+,n) = S^\rho_z(e^+).S^\rho_z(n)+S^\phi_z(e^+).S^\phi_z(n)$$
$$=\sqrt{\frac{3}{2}}A_eA_ne^2\kappa^4.\frac{xy}{X^2}J_1(\chi)\text{Sin}(Y)\frac{(x-\eta\alpha_1\text{Cos}(\phi))}{\chi}\left\{\frac{G_1(X)}{X}-G_1'(X)\right\}$$

$$\Sigma_t(e^+,n) = S^\rho_t(e^+).S^\rho_t(n)+S^\phi_t(e^+).S^\phi_t(n)$$
$$=\sqrt{\frac{3}{2}}A_eA_ne^2\kappa^4x\frac{G_1(X)}{X}J_1(\chi)\text{Cos}(Y)\frac{(x-\eta\alpha_1\text{Cos}(\phi))}{\chi}$$

Where $G_1'(X)=-\left(\frac{\text{Sin}(X)}{X}+\frac{2G_1(X)}{X}\right)$ & $J_1'(\chi)=J_0(\chi)-\frac{J_1(\chi)}{\chi}$

Hence, the interaction energy density in the common overlap region is,

$W_{int}(e^+,n) = (1/\varepsilon_0)[\Sigma_\rho(e^+,n) + \Sigma_\phi(e^+,n) + \Sigma_z(e^+,n) + \Sigma_t(e^+,n)]$ ....(30)

This energy density function is completely time invariant and is a function of independent parameters ρ, ϕ, z, δ and η. As usual the total interaction energy of the strong interaction between a nucleon core and a positron core considered above, will be obtained by integrating $W_{int}(e^+,n)$ over the entire volume of the common overlapped region.

$E_{int}(e^+,n)= \iiint W_{int}(e^+,n).\rho.d\rho.d\phi.dz$ ....(31)

7.4 The volume integral at equation (31) above, with variable limits of integration for the common overlapped region of two cores, can be evaluated through computerized numerical integration. For any given set of separation parameters δ and η, a unique value of interaction energy will be obtained. If the radial separation parameter η is set to zero, χ will reduce to x and the interaction energy obtained from equation (31) may be termed axial interaction energy of the e^+,n pair. If on the other hand δ is set to zero, Y will reduce to y and equation (31) will then provide pure radial interaction energy of the e^+,n pair. The axial and radial interaction energy of the positron, nucleon cores thus obtained is plotted at figures 5 & 6 for various separation distances. These are important plots which show maximum negative interaction energy of about 20 MeV between two cores when their centers coincide. The radial interaction energy is positive for core separation between 1.7 f to 3.7 f . We may even compute the whole set of values of interaction energy between the positron and nucleon cores for all possible values of δ and η to finally obtain an energy contour plot as shown in figure 7. In this figure the innermost contour correspond to the interaction energy of -19 MeV and the outermost to -1 MeV. This is a unique plot depicting the interaction energy characteristics of a positron entrapped within the proton core. From this data we can even compute the magnitude and direction of force experienced by the positron when its center is located at any point within the proton core. For example the positron experiences maximum radial inward force of about 2600 Newton at a radius of 1.2 f and a maximum radial outward force of about 600 N at a radius of 3 f. A plot of positron inward radial force within the proton core is shown at figure 8. Similarly in axial direction, the positron experiences a maximum inward force of about 1400 N at a distance of 1 f from the center of the nucleon core.

Figure 5

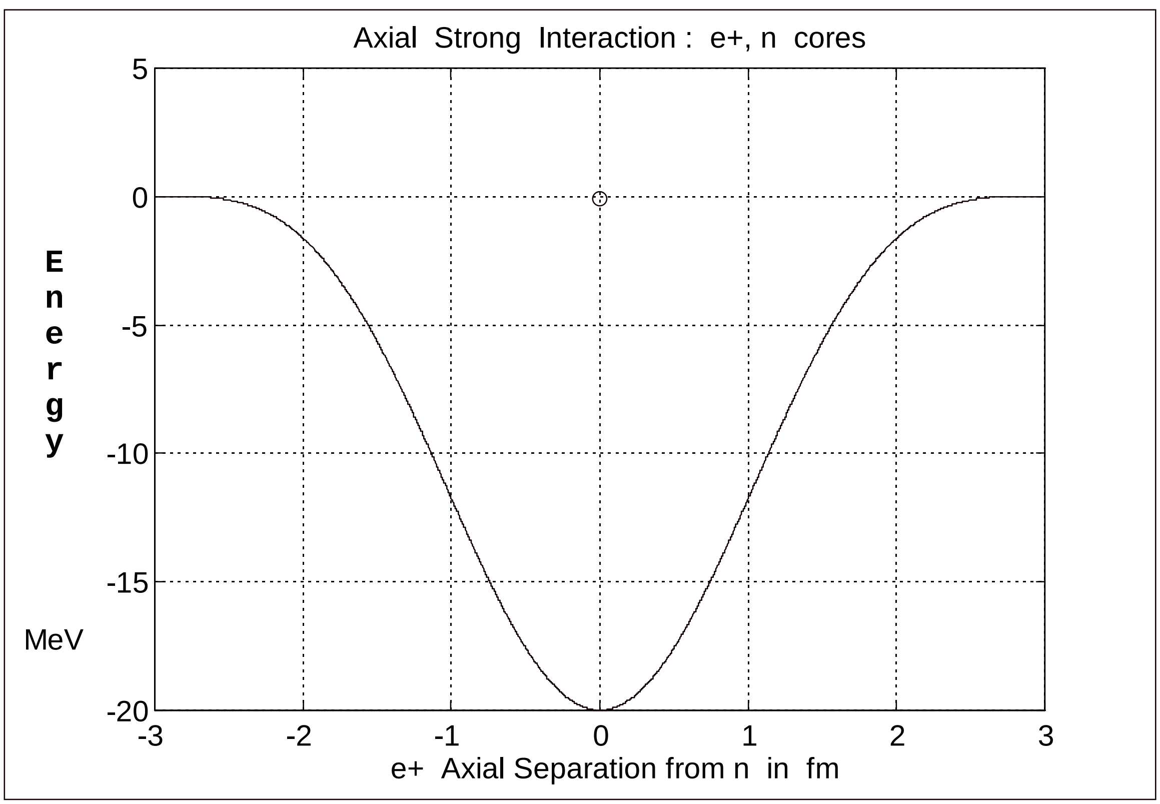


Figure 6

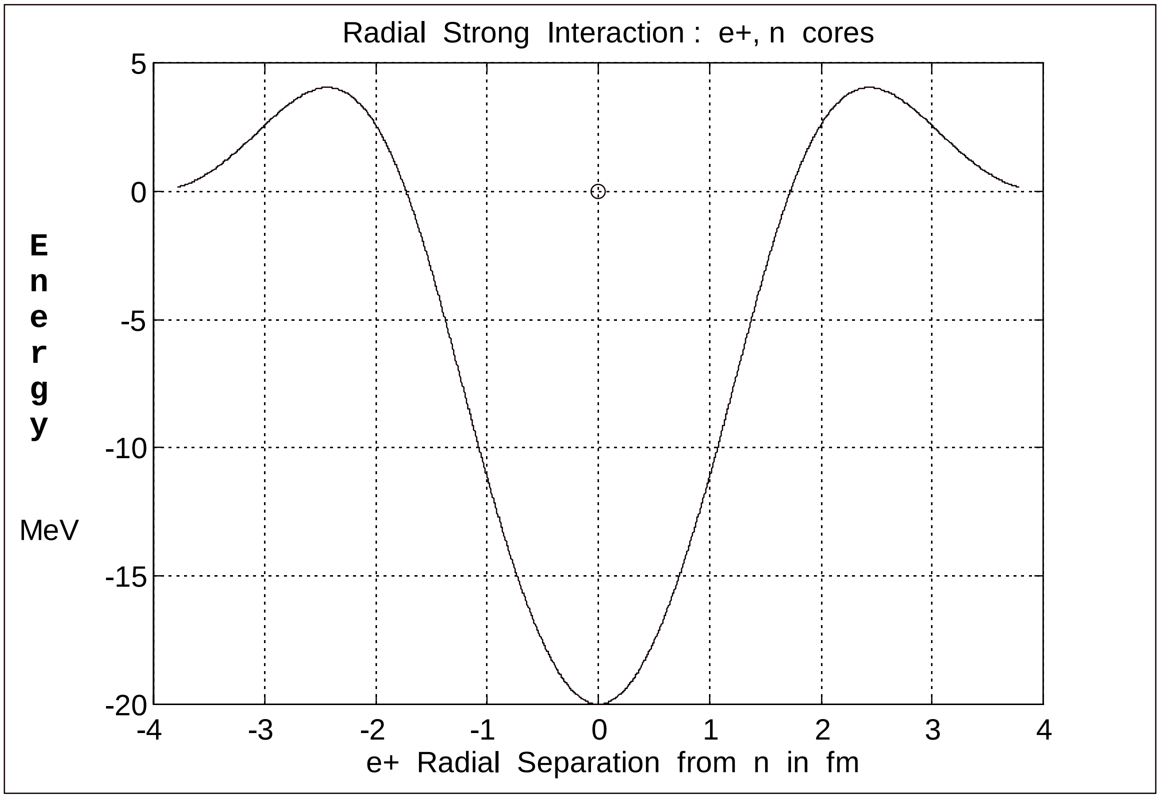


Figure 7

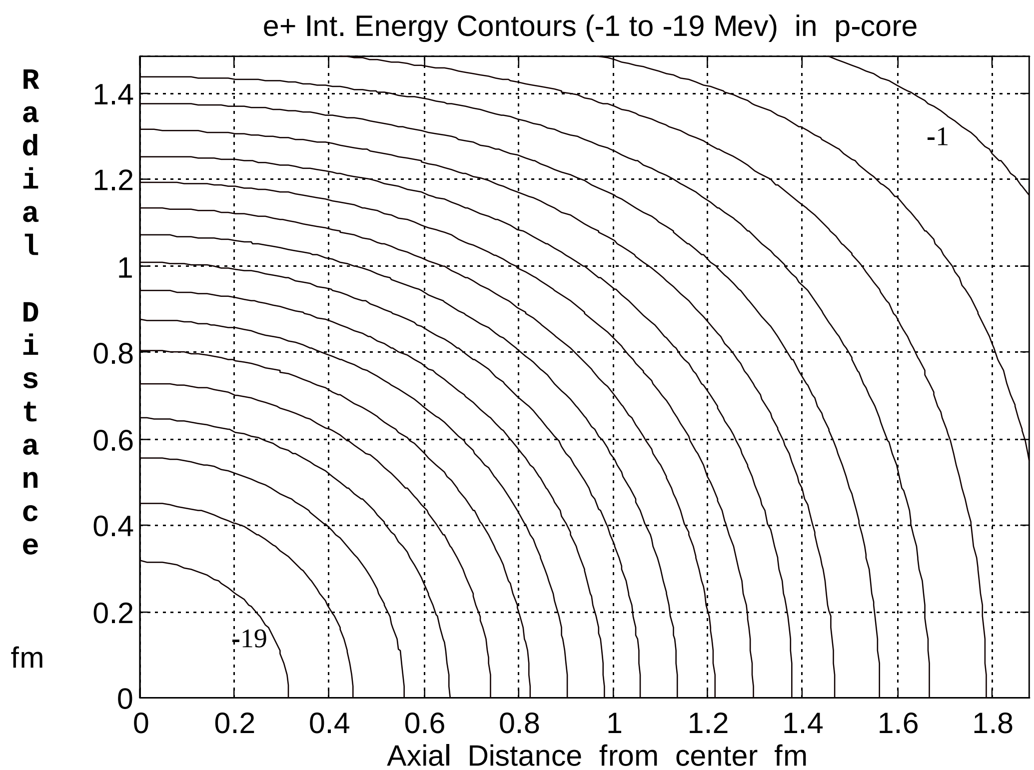
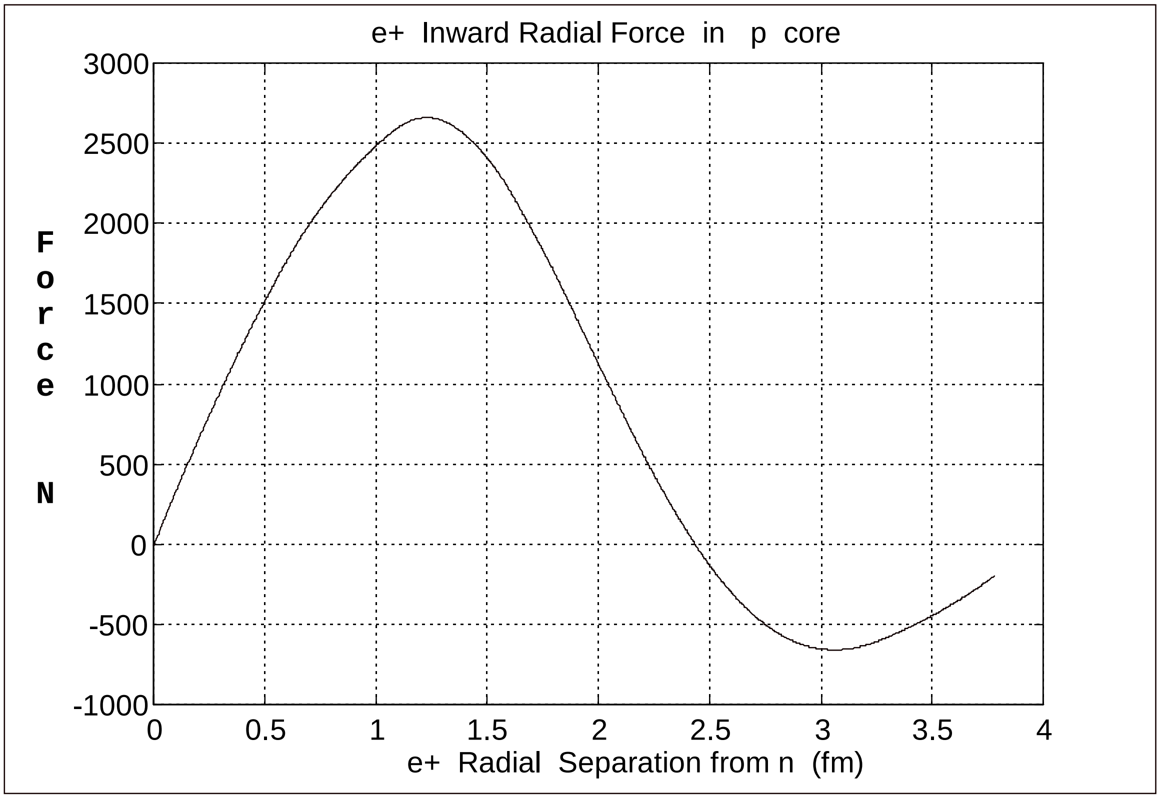


Figure 8

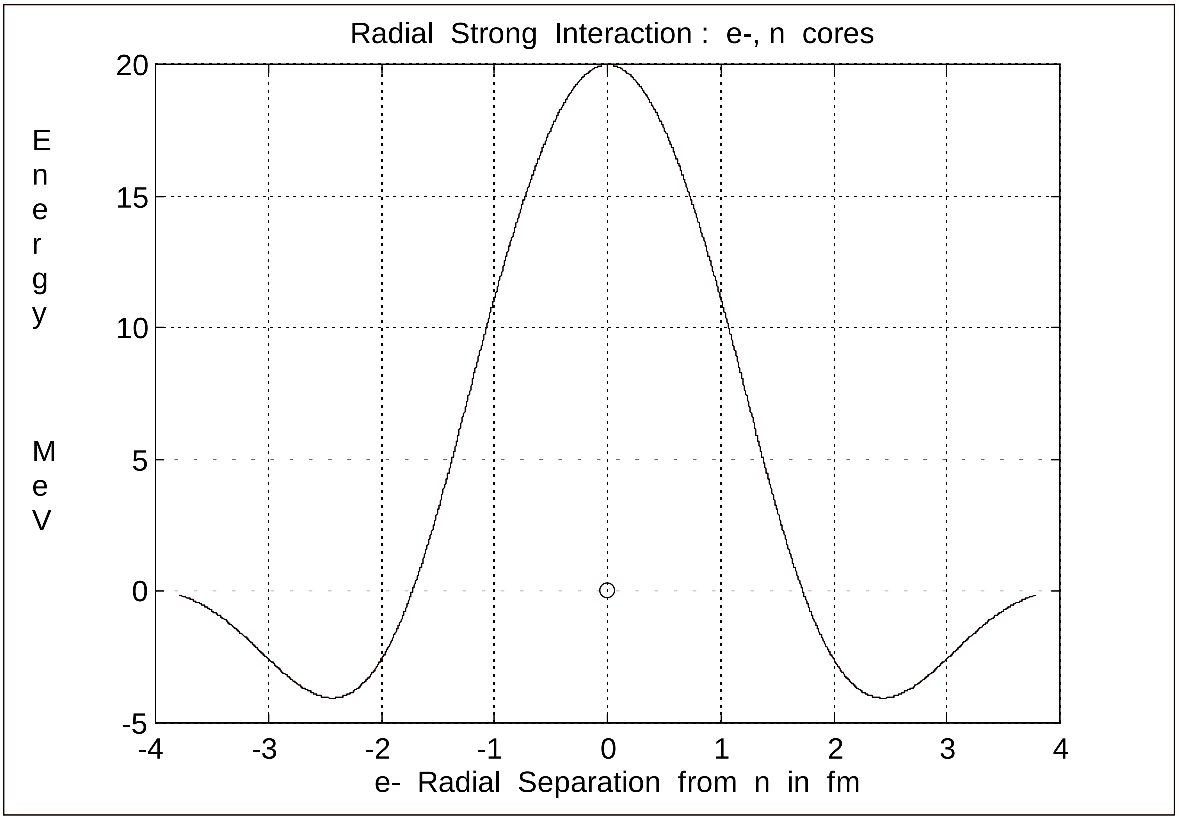


7.5 From the above mentioned data of the interaction energy and the associated force field acting on the positron entrapped within the nucleon core, we can make a fairly good estimate of the elliptical orbit on which the positron will move. With an estimated 1.8 MeV energy emitted out, balance amount of interaction energy is converted to the kinetic energy of the positron. From relativistic considerations the orbital velocity of the positron is estimated at 0.999 c, with corresponding orbital frequency $N_r = 5.4533 \times 10^{22}$ Hz. The major axis of this elliptical orbit is estimated at 2a=1.8384 f and the minor axis 2b = 1.6556 f . While the major axis lies along the principal transverse plane, the minor axis lies in an axial plane of the nucleon core. Axis of the elliptical orbit passes through the center of nucleon core and is inclined to the core axis at an angle of θ = 47.622 degree. Further, since the force field experienced by the positron is not exactly central, the positron orbit is also expected to precess around the nucleon core axis. The positron moving around the center of nucleon core on the above mentioned orbit will obviously produce a magnetic moment, the effective component of which along the core axis is given by,

$$\mu_p = eN_r.\pi ab.\text{Cos}(\theta) = 1.407 \times 10^{-26} \quad \text{Am}^2 \ .$$

This is the familiar anomalous magnetic moment of the proton. Therefore we may conclude that the proton consists of a positron entrapped inside a nucleon core through strong interaction and moving around in elliptical orbits inclined to the nucleon core axis.

Figure 9

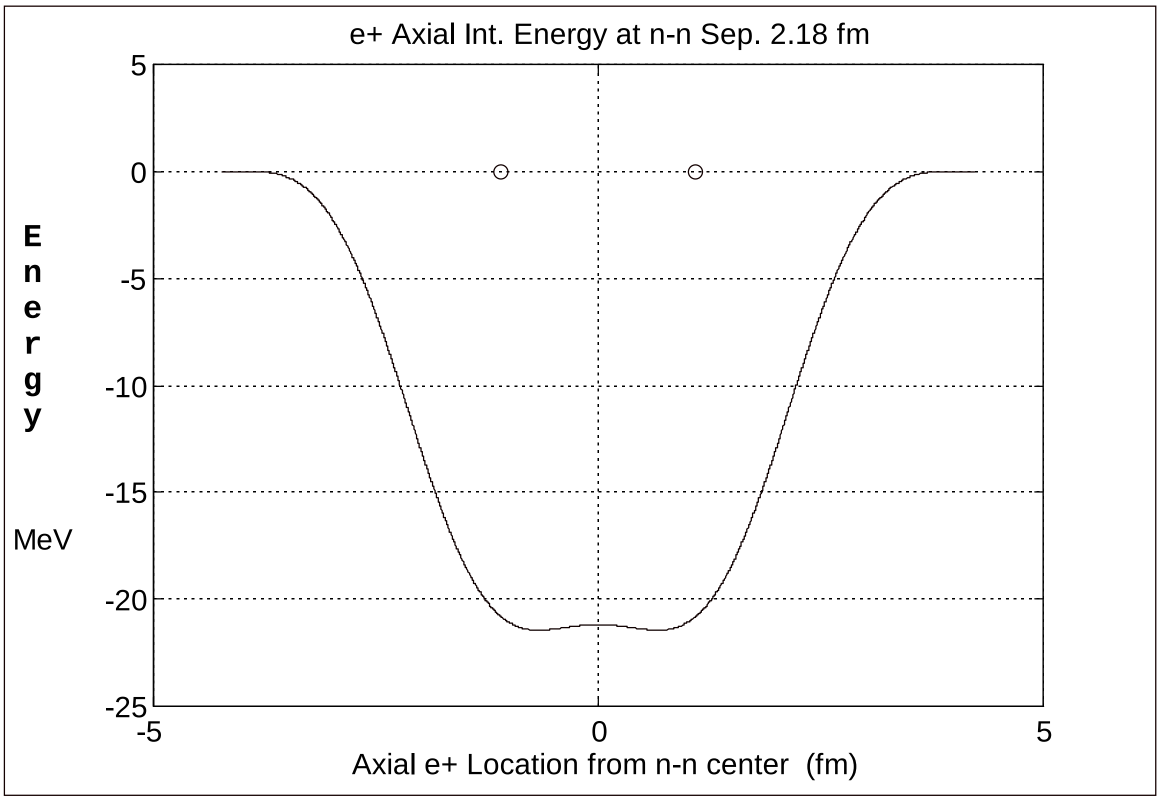


8. THE NUCLEON BONDS

8.1 The Neutron. When the strong interaction between an electron and nucleon cores is computed, we find the interaction curves given above just get reversed as shown in figure 9. That is, the electron core is found to have a negative interaction energy at radial separation of more than 2 fm or so. Thus under optimum conditions a proton can entrap an electron within the outer boundary of the nucleon core to form a neutron. The electron thus entrapped through strong interaction with nucleon core, is also expected to move in elliptical orbits within about 2 to 3 fm radius from the core axis. Therefore, a neutron consists of a nucleon core with a positron entrapped within its central region and an electron entrapped in its peripheral region. The formation and decay of the neutron is governed by the dynamic transfer of interaction energy between the orbiting electron and positron pair under suitable conditions. As seen from the interaction energy curves, the positron is much more tightly bound within the central region of the nucleon core, in comparison with the electron which is lightly bound in the peripheral region.

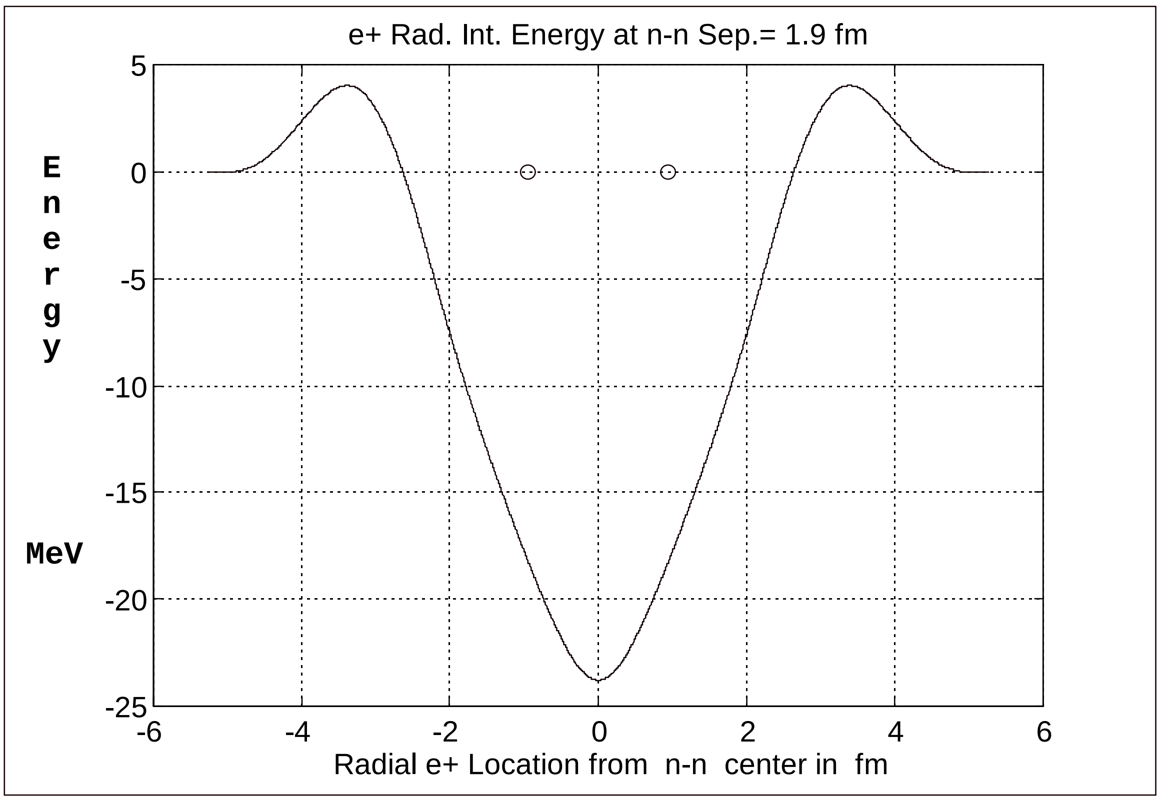
8.2 The p-n Axial Bond. As already indicated above, the presence of electron and positron plays a major role in the bonding of nucleons together since there must be a valid mechanism available for emitting out a portion of the released interaction energy out of the system. The interacting nucleons by themselves do not appear to possess any such mechanism. In an axial proton-neutron bond forming 'deuteron', the orbiting particles keep axially shifting from one nucleon core to the other after each cycle of rotation. Since the axially interacting nucleon cores tend to vibrate at a frequency of about 5.2×10^{22} Hz, the orbiting particles will give off a part of their kinetic energy to synchronize their motion with the nucleon oscillations. During each cycle of their oscillations, when the nucleon cores are closest together at a separation distance of about 2.18 f , the orbiting particles will tend to be in their mid section or equidistant from them. The combined interaction energy plot of a positron interacting with two nucleon cores separated by 2.18 f is shown at figure 10.

Figure 10



8.3 <u>The p-n Radial Bond.</u> As pointed out at para 6.7 above, two nucleon cores when coupled radially, will tend to vibrate at a frequency of about 3.6×10^{22} Hz with a minimum separation of about 1.9 f between their axes. The combined radial interaction energy plot of a positron interacting with two nucleon cores radially separated by 1.9 f is shown at figure 11. Here again the orbiting positron and electron will tend to synchronize their motion with radial vibrations of interacting nucleon cores by radiating out a portion of their kinetic energy. The amount of energy thus radiated out by the orbiting particles will become the effective bond energy of this p-n coupling. This bond energy is relatively a very small fraction of the total kinetic energy available in the system that sustains vibrations and rotations of constituent nucleons and orbital motion of the entrapped particles. There is one very important feature of the synchronous orbital motion of electron positron pair within a radial p-n coupling. The combined orbit of positron as well as electron around two radially coupled nucleon cores will be of the shape of figure of 8 . If the sense of orbiting particle motion around one nucleon core is clockwise, it will be anti- clockwise around the second core. This fact might be responsible for creating the general impression that conventional spins of two nucleons are parallel for their axial coupling and anti-parallel for their radial coupling. However, there appears to be some mix-up of intrinsic spin concept, orbital motion of orbiting particle and the mechanical rotational motion of nucleons in the conventional concept of nucleon spin. Since neither two positrons nor two electrons can jointly share a crossed orbit in the figure of 8, a radial p-n coupling can not occur in isolation. Thus a deuteron will consist of only an axially coupled p,n pair. A third nucleon can join a deuteron through above mentioned radial coupling. Further detailed study of motion of the positron and the nucleons under their mutually interactive environment, may require the use of revised Quantum Mechanics.

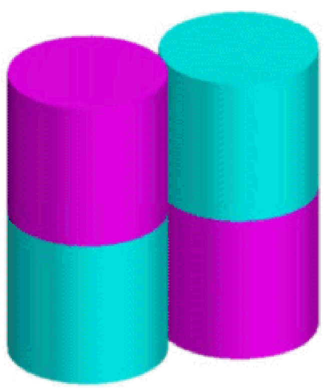
Figure 11



9. THE NUCLEUS

9.1 The nucleus consists of an assembly of nucleons, arranged in a definite order, each nucleon partly overlapping and hence strongly interacting with its adjoining nucleons. Since the nucleon core is of cylindrical shape with 2.7 f radius and 3.1314 f length, the nucleus built up from these nucleons will also tend to be cylindrical in shape. Moreover this assembly of nucleons is not static (like bricks assembled together with cement mortar) but highly dynamic with each nucleon vibrating vigorously about certain mean overlap positions. Since in the radial p-n coupling, mean separation between the vibrating nucleon cores is about 2.7 f and in the axial p-n coupling the mean separation is about 2.6 f , we may take the effective 'contact' diameter of the nucleon as 2.7 f and effective contact length of the nucleon as 2.6 f for the purpose of developing a 'static' picture of the nucleus. The nucleons of this effective size may now be assembled in specific radial arrangements, repeated in axial layers (containing different number of nucleons) to build up a nucleus of the required size. In general the central layers will contain maximum number of nucleons and the layers at the two ends of the axis will contain minimum number, such that the overall nucleus with its inherent synchronous vibrations and rotations, will appear to be approximately spherical in shape. Let us term the contact diameter as D_c and the contact length as L_c so that D_c= 2.7 f and L_c= 2.6 f . With this terminology we can say that the effective mean 'contact' size of deuteron is : diameter $1D_c$ and length $2L_c$. The α particle consisting of four nucleons is essentially a radial coupling of two deuteron particles. The shape of α particle will therefore be a cuboid of length $2L_c$, breadth $2D_c$ and thickness $1D_c$ (Figure 12a). It is very important to point out here that the assembly of four nucleons in radially coupled 'square' configuration, is dynamically unstable (Figure 12b). The reason for this instability is that in such a configuration the separation distance between diagonally opposite nucleons will fall in the positive interaction energy hump of the radial interaction energy curve, figure 4, during a part of their oscillation cycle and hence tend to make them fly apart.

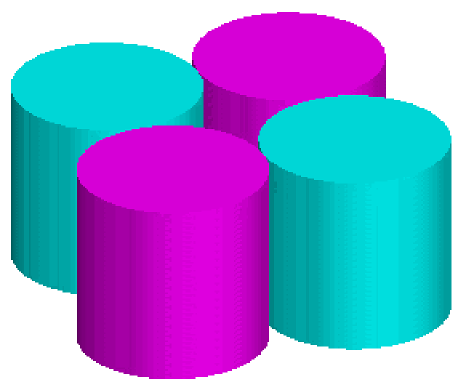
Figure 12a



4 nucleon stable configuration

forming α particle

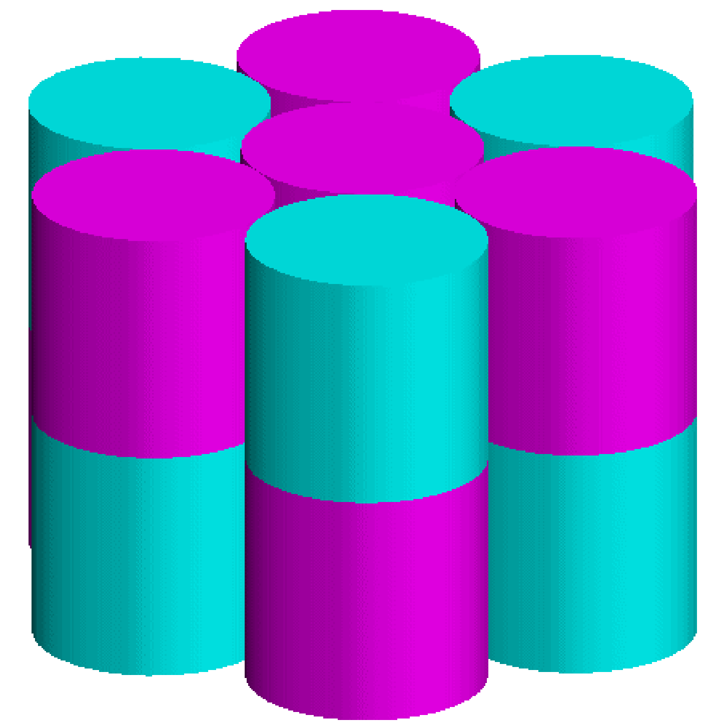
Figure 12b



4 nucleon unstable configuration

9.2 Presently the most stable arrangement for radial coupling of nucleons is the hexagonal close packed (hcp) configuration in which all nucleons in a particular radial or transverse plane are located on the corners and the center of a regular hexagon. All nucleons arranged in hcp configuration in a particular transverse plane may constitute, what we may call a transverse layer of nucleons of $1L_c$ axial thickness. Two identical transverse layers of nucleons may get axially coupled when each proton in one layer is axially coupled to a neutron in the second layer and vice-versa. At any instant of time, the total number of protons and neutrons may be equally distributed between two such layers. Such a double layer of nucleons may also be visualized as a single transverse layer of deuteron particles. For an example we may consider the nucleus of carbon $_6C^{12}$ which will consist of a single transverse layer of 6 deuteron particles arranged on the corners of a regular hexagon. Similarly the nucleus of $_7N^{14}$ will consist of a single transverse layer of 7 deuteron particles arranged on the corners and center of a regular hexagon as shown at figure 13. However this is just a representative 'static' picture made from the effective mean contact diameter mentioned above. Actual dynamic picture of the nucleus with its vibrations and rotations, may be quite different depending upon the mode of observation. The actual radial and axial configuration of nucleons in any particular nucleus could be worked out in detail from the available experimental data about that nucleus.

Figure 13



14 Nucleon configuration
$_7N^{14}$ nucleus

10. SUMMARY AND CONCLUSION

10.1 The model of nucleon developed in this paper is based on a cylindrical strain bubble solution of equilibrium equations of elasticity in the Elastic Continuum. This strain bubble is stable, finite in size with cylindrical symmetry and oscillates at a frequency that matches with the oscillation frequency of electron/positron cores. From the detailed study of this model, we find that the nucleon core is of the shape of a right circular cylinder of radius 2.7 f and length 3.1314 f and the moment of inertia about its axis equal to I_n= 4.6259×10^{-57} kg.m^2 . As per the ECT[1] all interactions take place through the superposition of strain fields of interacting particles and are not mediated through the exchange of any particle whatsoever. Accordingly, detailed computations have been made to obtain interaction energy data for various axial & radial separations of interacting nucleons on the one hand and for the positron core interacting with nucleon on the other. This interaction energy data implies that two nucleons are likely to get radially coupled together under suitable conditions and oscillate at a frequency of about 3.6×10^{22} Hz with mean radial separation of about 2.7 f . Two nucleons are also likely to get axially coupled together under suitable conditions and oscillate at a frequency of about 5.21×10^{22} Hz with mean axial separation of about 2.6 f . The positron, through its strong interaction with nucleon core, gets entrapped within the nucleon and moves around in elliptical orbits at a frequency of 5.4533×10^{22} Hz. This orbital motion of the positron is shown to be the source of anomalous magnetic moment of the proton. The nucleus is shown to mainly consist of layers of radially coupled deuterons or nucleons arranged in hcp configuration.

<u>References</u>

[1] Elastic Continuum Theory of Electromagnetic Field and Strain Bubbles by the Author

[2] The Electron Structure and Coulomb Interaction ,,