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The Bag constant of composite fermionic structures in a cold genesis theory of particles

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Abstract

The paper presents a better calculation of the constants P_{si}^0 and δ of the CGT's bag model, previously publised, which indicates the existence of a bag pressure (and a bag constant) for each composite particle but also for quarks and the bag's constant variation with the intrinsic temperature of the particle's kernel.

1. Introduction

In a Cold genesis theory of particles [1, 2] , the strong force of quarks confining and the nuclear force were explained by a (multi)vortical model of nucleon, considered as cluster of an even number N^p = 1836/0.8095 = 2268 quasielectrons, (integer number of degenerate "gammons", $\gamma^*(e^{*-} e^{*+})$), i.e. electrons with degenerate charge ($e^* = \pm(^2/_3)e$), magnetic moment $\boldsymbol{\mu}^*$ and mass: m_e^* = 0.8095 m_e, resulting by a degeneration of the magnetic moment's quantum vortex $\boldsymbol{\Gamma_\mu = \Gamma_A + \Gamma_B}$, given by 'heavy' etherons of mass $m_s \approx 10^{-60} kg$ and 'quantons' of mass $m_h = h\cdot 1/c^2 = 7.37\text{x}10^{-51}$ kg.

The considered "gammons" were experimentally observed in the form of quanta of "un-matter" plasma, [3].

The m_e^* -value results in CGT by the conclusion that the difference between the masses of neutron and proton: ($m_n - m_p \approx 2.62\ m_e$) is given by an incorporate electron with degenerate magnetic moment and a linking 'gammon' $\sigma_e(\gamma^*) = 2m_e^* \approx 1.62\ m_e$, forming a 'weson', $w^- = (\sigma_e(\gamma^*) + e^-)$, which explains the neutron in a dynamide model of Lenard- Radulescu type [1, 2], (protonic center and a negatron revolving around it by the $\boldsymbol{\Gamma_\mu}$-vortex with the speed $v_e^* <<$ c, at a distance $r_e^* \approx 1.36$ fm [4]- close to the value of the nucleon's scalar radius: $r_0 \approx 1.25$ fm used by the formula of nuclear radius: $R_n \approx r_0 \cdot A^{1/3}$), at which it has a degenerate μ_e^S -magnetic moment and S_e^n–spin.

The used electron model supposes an exponential variation of its density, $\rho_n(r)$, given by photons of inertial mass m_f , vortically attracted around a dense kernel m_0 and confined in a volume of classic radius a = 1.41 fm, (the e-charge in electron's surface), the superposition of the (N^p+1) quantonic vortices Γ_μ^* of the protonic quasielectrons, generating a total dynamic pressure: $P_\mu(r) = (1/2)\rho_\mu(r)\cdot c^2 \leq (1/2)\rho_n(r)\cdot c^2 = P_n(r)$, inside a volume with radius: d^a = 2.1 fm, which gives an exponential nuclear potential: $V_n(r) = -\upsilon_i P_\mu(r)$ of eulerian form, conform to :

$$V_n(r) = \upsilon_i P_\mu(r) = V_{n0}\cdot e^{-r/\eta^*}; \qquad V_{n0} = -\upsilon_i P_{\mu 0}\,, \tag{1}$$

with: $\eta^* = 0.8fm$ (equal to the root-mean-square radius of the magnetic moment's density variation inside a neutron, experimentally determined) and υ_i(0.59÷0.6fm)- the 'impenetrable' volume of nuclear interaction [1, 2], the proton resulting as formed by $N^p \approx 2268$ paired quasi-electrons which give a proton's apparent density in its center (by the sum rule), of value: $\rho_n^o \approx f_c \cdot N^p \cdot \rho_e^o = 4.54\text{x}10^{17} kg/m^3$, ($\rho_e^0 = 22.24\ \text{x}10^{13}\ kg/m^3$), and an attached positron with degenerate magnetic moment, in the CGT's model, the density of the $\boldsymbol{\Gamma_\mu}$-vortex of a free electron having approximately the same density' variation as the density of photons of its classic volume (of radius a = 1.41 fm), $f \approx 0.9$ being a coefficient of mass' and $\boldsymbol{\Gamma_\mu}$-vortex's density reducing in the center of the (quasi)electron at its mass degeneration, its value resulting by the gauge relation of CGT: $e = 4\pi a^2/k_1$ and by the integral of nucleon's mass – considered as given by confined photons, with a density variation: $\rho_n(r) = \rho_n^0(0).e^{-r/\eta'}$ with η' = 0.87 fm, (equal to the proton's root-mean square charge radius, experimentally determined: 0.84 ÷0.87 fm).

Eq. (1) with $\upsilon_i(a_i) \approx (0.86\div 0.9)\,fm^3$, gives a value $V_n^0 = (110\div 115)\ MeV$ and: $V_n(d=2fm) \approx (8.6\div 9)\ MeV$ – value specific to the mean binding energy per nucleon in the nuclei with the most strongly bound nucleons, (~ 9 MeV/nucleon for ^{56}Fe, ^{58}Fe, ^{60}Ni, ^{62}Ni).

It is know also the MIT bag model of particle (Chodos et al., 1974, [5]), based on Bogoliubov's model (1967) and the Quantum chromodynamics, which consider the quarks moving inside a „bag" volume of radius R≈1fm , with the normal component of the pressure exerted by the free Dirac particles inside the bag balanced at the surface by the difference in the energy density of the quantum vacuum inside and outside the bag:

$$E = (4\pi/3)B\cdot R^3\ , \qquad \text{with } B \approx 58 MeV/fm^3\ , \qquad (2)$$

the B-constant having the meaning of a quantum vacuum pressure.

The quarks' confining is explained in CGT by a similar „bag" model [6], considering similarly a pressure of quanta specific to the quantum vacuum, but with the difference that these radially kinetized quanta are a relative small part of the nucleon's quantonic clusters forming ‚naked' photons (i.e. photons reduced to their inertial mass: $m_f = h\nu/c^2 \geq m_h$, contained by a photon's kerneloid of radius $r_f < 10^{-17}$ m and volume υ_f), which are radially vibrated at the surface of the 'impenetrable' volume of nuclear interaction, $\upsilon_i(a_i)$, considered of a radius $a_i \approx 0.6$ fm - used in the Jastrow's expression for the nuclear potential [7], as consequence of the vortical field's attraction by a scalar potential of the form (1), i.e. $V_f(r) = ½\upsilon_f\rho_\mu(a_i)c^2$; (with υ_f instead of υ_i), the generated bag's potential being considered as resulting by a Gaussian variation of the vibrated photons' kinetic energy density, in the form:

$$V_{qn} = \upsilon_q \cdot P_{sc} = \upsilon_q \cdot P_{si}^0 \cdot e^{-\left(\frac{r-a_i}{\delta}\right)^2} = V_{qn}^0 \cdot e^{-\left(\frac{r-a_i}{\delta}\right)^2} \qquad (3)$$

in which $\upsilon_q(m_q;\upsilon_q)$ is the (u/d)-quark's quantum impenetrable volume $\upsilon_q(r_q)$, considered of radius $r_q \approx 0.2$ fm –conform to older experiments [8], $a_i = r_i^* \approx 0.6\,fm$ and: $\delta = \sqrt{2}c$, (c–the gaussian standard deviation).

The value of $P_{si}^0 = \rho_f(a_i)c^2$ (the pressure on the bag's surface) resulted close to that obtained by the MIT bag model ($10.2\text{x}10^{33}\ N/m^2$ instead of $9.3\text{x}10^{33}\ N/m^2$), but by a roughly approximation ($\rho_f(a_i) \approx ½\rho_n(a_i)$; $\rho_n(r)$- the nucleon's density), the δ -constant resulting of 0.27 fm by the conclusion that the known quarks deconfination temperature: $T_d \approx 2\text{x}10^{12}$K, ([9], Karsch, 2001), is given in accordance with the equation :

$$E_D = \frac{1}{2}k_B T_d = \frac{m_n}{m_q}(V_{qn}(r^*) - V_c^*) \approx 175 MeV \qquad (4)$$

in which: $r^* \approx 0.45$fm and $V^*_c = (½)\cdot m_q v_r^2 \approx 2.6\text{x}10^{-3}$ MeV -the centrifugal potential, i.e. by the conclusion that the mechanic work of the mean force $F_q(r) = -\nabla V_{qn}$ must cancel the kinetic energy $E_{qv} = (m_q/m_n)E_D$ obtained by a current (u/d)- quark, until the bag's surface.

It was also argued in CGT [10] that the current d-quark's mass $m_d \approx 7.5$ MeV/c^2 is more plausible than the value: $m_d \approx 5.2$ MeV/c^2 -actually used in the Standard Model.

The purpose of this paper is a better calculation of the constants P_{si}^0 and of the δ-constant, by the CGT's bag model, which indicates the existence of a bag pressure (and a bag constant) for each composite particle.

2. Argument for CGT's calculation of the bag constant's value

A supplementary justification of the current quark's radius : $r_q^n \approx 0.2$ fm used in CGT for the real volume of a dilated current mass of an u/d-quark of a nucleon having an ordinary temperature $T_n^j \approx 1$MeV/k_B, instead of the value: $r_q^{\bullet} = 0.43 \times 10^{-3}$ fm –actually considered by the S.M. , is the next:

The known MIT bag model considers the current quarks and the gluons as light particles with radius $r_q^{\bullet} < 10^{-3}$ fm moving inside a „bag" volume of radius R ≈ 1fm , with the normal component of the pressure exerted by the free Dirac particles inside the bag balanced at the surface by the difference in the energy density of the quantum vacuum inside and outside the bag: $\Delta E = (4\pi/3)B\cdot R^3$, corresponding to ¼ of the nucleon's rest energy, with B ≈ 58MeV/fm^3 [11], the B-constant having the meaning of a quantum vacuum pressure. Conform to this model, the quark confinement is explained by a potential similar to the Cornell potential: $V_{qC} = -\frac{k_1}{r} + k_2 \cdot f(r)$, (with a pseudo-Coulombian term of color charges interaction by gluon exchange and a strong force term corresponding to an elastic force as that generated by an elastic string formed between a pair of quarks), but with the second term in the form : $B\cdot V = (4\pi/3)BR^3$, i.e. by a pressure force:

$F_t = 4\pi BR^2$, with B ≈ 58MeV/fm^3 = 9.28×10^{33} N/m^2. But for a current quark with a supposed radius $r_q^{\bullet} = 0.43 \times 10^{-3}$ fm, the resulting B-value gives a specific force:

$F_q^{\bullet} = \pi r_q^{\bullet 2}\cdot B = 5.39 \times 10^{-3}$ N –of very low value.

If a nucleon has a vibration energy $E_v = 1.4 \times 10^{-13}$J = 0.875 MeV, corresponding to a nuclear temperature $T_n' \approx 10^{10}$ K, the energy E_q transmitted to a current quark of mass $m_q \approx 3$ MeV/c^2 is: $E_q = (m_q/m_n)E_v = (3/938)0.875 = 0.0028$ MeV ≈ 4×10^{-16} J – much higher than the mechanic work of the force $F_q^{\bullet}$ (considered constant) on the distance Δr ≈ 1 fm,

($L(F_q^{\bullet}) = F_q^{\bullet}\Delta r \approx 5.4 \times 10^{-18}$ J), which lead to the conclusion that the current quark could penetrate the bag's surface even at an ordinary nuclear temperature T_n^j, without the interaction with the other two quarks by 'color charge' (concept not enough explained micro-physically) and that the $F_q^{\bullet}$ -force cannot explain the current quark's 'asymptotic freedom'.

3. The calculation of the bag constants B and δ of the CGT' model of strong interaction

a) Because the nucleon's rest energy: $E_N = m_n c^2 = 938$ MeV corresponds to a virtual temperature $T_N = E_N/k_B \approx 1.087 \times 10^{13}$ K, the deconfining energy $E_D = 175$ MeV experimentally determined corresponds to a nucleon's associated temperature: $T_D = (E_D/E_N)T_N \approx 2 \times 10^{12}$ K.

However, for a nucleon's impenetrable volume containing three current quarks of mass $m_q \approx 7.5$ MeV/c^2, (the difference δm ≈ 2.6 m_e being given by the masses of the constituent quarks, in CGT), only a fraction $R = E_{qv} = (m_q/m_n)E_D \approx 1.4$ MeV is transmitted to a current quark.

Conform to CGT [6], the quarks' deconfining is produced when a current quark penetrate the bag's surface generated by their common vortical field, i.e. when it has –relative to at least one other current quark of the same nucleon, (figure 1), an energy:

$$E_{qv} \approx V_q^0(a_i) = (m_q/m_n)E_D \approx 1.4 \text{ MeV}, \quad (5)$$

with $V_q^0(a_i) = \upsilon_q \cdot P_{si}^0$; ($\upsilon_q = \upsilon_q(0.2\text{fm})$ –the current quark's volume, in CGT, [2], in concordance with older experiments [9]), P_{si}^0 being the bag's pressure: $P_{si}^0(a_i)$, given by naked photons mixed with quantons, radialli kinetized toward the nucleon's center, ($v_f \uparrow\downarrow r$).
The equality (5) is justified by the fact that the inter-quarks potentials: magnetic, $V_{q\mu}$, and centrifugal, V_{qc}, are sensible smaller and they are reciprocally compensated [6].

For a maximal speed: $v_f = c$ of the radially vibrated ‚naked' photons of the bag's surface, we can approximate that: $P_{si}^0(a_i) \approx ½\rho_f(a_i)c^2$, with $\rho_f(a_i)$ –the density of vibrated photons.
It results from Eq. (5) that $P_{si}^0(a_i) = 6.69\text{x}10^{33}$ N/m^2, corresponding to: $B_i \approx 42$ MeV/fm^3, –for $v_f \uparrow\downarrow r$, ($½\rho_f(a_i)$).

It must be mentioned that the obtained values of $P_{si}^0(a_i)$ and B_i correspond to an interaction state, i.e. to a value specific to the interaction between two nucleons, and each nucleon increases the quantonic dynamic pressure at the surface of the impenetrable quantum volume (‚kerneloid') of the other nucleon, with a higher value between their kerneloids (in A-point) compared to the value in the opposed B-point.
But in the opposed point B, the increasing of the dynamic pressure $P_{di}^i(d_i^0)$ is realised with a negative gradient δP_{di}^i in report to the nucleon's radius r_n, i.e. corresponding to an attractive potential of the form (1): $V_f(r) = ½\upsilon_f\rho_\mu(a_i)c^2$, acting over the volumes of ‚naked' photons, this corresponding- conform to the explanatory model, to an increasing of the bag's constant value.

However, conform to the Bernoulli's law, the increasing of the quantonic dynamic pressure $P_{di}^i(d_i^0) = ½\rho_\mu(d_i^0)c^2$ reduces locally the static quantum pressure, but in our case- i.e. for the $P_{si}(a_i)$ corresponding to the photon's speed $v_f \uparrow\downarrow r$, it results that this effect can be considered as compensated by the effect of the $V_f(r)$- potential in the B-point (opposed to the A-point), while at the semi-surface of nucleon's kerneloid corresponding to the A-point, the gradient δP_{di}^i introduced by the second nucleon is positive in report to the r_n -radius of the first nucleon, diminishing the total potential $V_f(r) = ½\upsilon_f\rho_\mu(a_i)c^2$, acting over the volumes of ‚naked' photons and diminishing also the local value of $P_{si}(r_i)$, ($r_i = d_i/2$), so the Bernoulli's law can be applied to the case of the semi-surfaces $S_i = 2\pi a_i^2$ oriented toward the A-point.

The nuclear force results in this case –with acceptable approximation, by the pressure difference between the value $P_{si}^B(a_i) \approx P_{si}^0(a_i)$ –specific also to the free state and the value: $P_{si}^A(r_i) \approx P_{si}^0(r_i) - P_{di}^i(r_i^0)$, ($P_{si}^0(r_i)$ –value of free state), acting on the interaction section $S_i = \pi a_i^2$.

b) - For the calculation of the δ-constant we use the approximation: $F_{qm} = V_q^0/a_i \approx V_q(F_{qM})/r_M$, i.e. the conclusion that –because the F_q –force's variation is between 0 and its maximal value $F_{qM}(r_M)$ on both intervals: ($0 \div r_M$) and (($r_M \div a_i$), the mean force F_{qm} is approximately equal to the intervals ($0 \div r_M$) and ((0 $\div a_i$), and of value: $F_{qm} = K_q \cdot F_{qM}$, i.e.:

$$F_{qm} = K_q F_{qM}(r_M) = V_q^0/a_i \approx V_q(F_{qM})/r_M = 373 \text{ N} \quad (6)$$

Also, because F_{qM} correspons to the equality: $d(F_q(r_M)/dr = 0$, it results that:

$$F_q = -\nabla V_q = -\upsilon_q \cdot \nabla P_{si} = 2\frac{\upsilon_q \cdot (r-a_i)}{\delta^2} P_{si}^0 \cdot e^{-\left(\frac{r-a_i}{\delta}\right)^2}; \quad \frac{dF_q(r_M)}{dr} = 0, \Rightarrow \delta^2 = 2(a_i - r_M)^2 \qquad (7)$$

From Eqs. (3), (6) and (7) it results that: $r_M = a_i \cdot e^{-0.5} = 0.364$ fm and: $F_{qM} = 575.7$ N.
So, from (6) and (7) it results that: $K_q = F_{qm}/ F_{qM} = 0.648$; $\delta = \sqrt{2}(a_i - r_M) = 0.3327$ fm.

4. The explaining of the nuclear force

The obtained value of $P_{si}^0(a_i)$, ($\sim 6.7\text{x}10^{33}$ N/m^2) must explain in CGT also the nuclear force, in the sense that the maximal attractive force between two nucleons, which is at an interdistance $d_i^0 \approx 2r_i^0 = 0.9$ fm (corresponding to the mechanic contact between the nucleonic kernels of radius $r_i^0 \approx 0.45$fm, formed by the nucleon's current quarks), must result in concordance with Eq. (1) by a pressure difference: $\Delta P_{si} \approx (P_{si}^0(a_i) - P_{si}(r_i))$, (with $P_{si}(r_i) << P_{si}^0(a_i)$; $r_i = d_i/2$), in concordance with the Bernoulli's law on the vortex line $l_r = 2\pi r$ inside the nucleon's volume having an exponential density' variation : $\rho_n(r) = \rho_n^0 \cdot e^{-r/\eta'}$, ($\eta' = 0.87$ fm):

$$P_{si}(r) + P_{di}(r) = P_{si}^*(r) \leq \rho_n(r)c^2 \; ; \; (\rho_n = \rho_n^0 e^{-r/\eta'}) \Rightarrow \Delta P_{si}(r) = -\Delta P_{di}(r), \qquad (8)$$

$\Delta P(r)$ being a pressure difference between two points A, B, diametrally opposed on the vortex line $l_{ri} = 2\pi r_i$: $\Delta P(r_i) = P_A(r_i) - P_B(-r_i)$ for the attracted nucleon (1_a), but produced by the vorticity of an attactor nucleon (2_a) for which the points A, B correspond to r_A and $r_B = r_A + 2r_i$.

For $d_i = 2r_i$, with $a_i = 0.59$ fm and $P_B(-r_i) \approx P_{si}^0(a_i)$, the nuclear force resulting by (1) is given by the pressure difference ΔP_{si} generated by light ‚naked' photons on surface $S(a_i)$:

$$F_n(d_i) = (1/\eta^*)V_n(d_i) \approx S(a_i) \cdot \Delta P_{si} \; ; \Rightarrow \pi(a_i)^2(P_{si}^B - P_{si}(r_i)) = (1/\eta^*)V_{n0} \cdot e^{-di/\eta^*}, \qquad (9)$$

-For $d_i \approx 1.2$ fm, ($r_i = a_i = 0.59$fm), by Eq. (1) it results: $V_{n0} = 110$ MeV; $V_n(d_i) = 24.54$ MeV;
$\Rightarrow F_n(d_i) = 24.54\text{x}1.6\text{x}10^{-13}\text{J}/0.8\text{x}10^{-15} = 4.9\text{x}10^3$ N , and- conform to (9):
$\Rightarrow \Delta P_{si} = 4.9\text{x}10^3/1.09\text{x}10^{-30} = 4.5\text{x}10^{33}$ N/m$^2 \approx P_{si}^B(a_i) - P_{si}(r_i) \approx P_{si}^0(a_i) - P_{si}(r_i)$.
By the explained approximation: $P_{si}^B(a_i) \approx P_{si}^0(a_i) = 6.69\text{x}10^{33}$ N/m^2, it results that:

$P_{si}(r_i) = P_{si}^A(a_i) = P_{si}^B(a_i) - \Delta P_{si} \approx P_{si}^0(a_i) - \Delta P_{si} = 2.19\text{x}10^{33}$ N/m$^2 = k_1 \cdot P_{si}^0(a_i)$
($k_1 = 2.19/6.69 = 0.3273$- for $d_i = 2a_i \approx 1.2$ fm).

-For $d_i = d_i^0 = 2r_i^0 = 0.9$ fm, we have: $P_{si}^B(a_i) \approx P_{si}^0(a_i) = 6.69\text{x}10^{33}$ N/m^2,
and compared to the case: $d_i = 2a_i$, $F_n(d_i)$ and $P_{si}(r_i)$ are changed -conform to the model.
By Eq.(9), with $S_i = \pi(a_i)^2 = 1.09\text{x}10^{-30}$ m^2, we have: $V_n(d_i^0) = 35.71$ MeV and:
$F_n(d_i^0) = 35.71\text{x}1.6\text{x}10^{-13}\text{J}/0.8\text{x}10^{-15} = 7.142\text{x}10^3$ N $\approx S_i \Delta P_{si}$, resulting:
$\Delta P_{si} = 7.142\text{x}10^3/1.09\text{x}10^{-30} = 6.552\text{x}10^{33}$ N/m$^2 \approx P_{si}^B(a_i) - P_{si}(r_i^0)$, and by $P_B(-r_i) \approx P_{si}^0(a_i)$,
it results that: $P_{si}(r_i^0) = P_{si}^A(a_i) \approx P_{si}^0(a_i) - \Delta P_{si} \approx 0.14\text{x}10^{33}$ N/m$^2 = k_1' \cdot P_{si}^0(a_i)$,
with $k_1' = 0.021$ and $P_{si}^0(a_i) = \rho_f^x(a_i)c^2 \approx \frac{1}{2}\rho_f(a_i)c^2$, ($\rho_f^x = \frac{1}{2}\rho_f$ corresponding to naked photons with: $v_f \uparrow\downarrow r$).

-By $P_{di}(d_i) = \frac{1}{2}\rho_\mu(d_i)c^2$, Eq. (9) for an attracted nucleon can also be written as:

$$F_n(d_i) = \tfrac{1}{2}\rho_\mu(d_i)c^2(1/\eta^*)(4\pi a_i^3/3) = \tfrac{1}{2}[\rho_f(a_i) - \rho_f'(r_i)]c^2(\pi a_i^2) = \tfrac{1}{2}\rho_f(a_i)c^2(\pi a_i^2)(1-k_1) \qquad (10)$$

because P_{si} is given by light photons with: $v_f \uparrow\downarrow r$, generating the repulsive potential (3).
- For $r_i = a_i$, ($d_i = 2a_i \approx 1.2$fm), by $P_{si}(r_i^0) = k_1 P_{si}^0 = 0.3273 P_{si}^0$, it results: $\rho_f'(r_i) = k_1\rho_f(a_i)$, ($\rho_\mu(d_i) = \rho_n^0 e^{-1.2/\eta^*} = 1.013 \times 10^{17}$ kg/m^3; $\eta^* = 0.8$ fm), and with:
$\rho_f(a_i) = 2P_{si}^0/c^2 = 1.486 \times 10^{17}kg/m^3 \approx 1.46177\rho_\mu(d_i) = k_{1p}\rho_\mu(d_i) = k_r\rho_\mu(d_i)/(1\text{-}k_1)$, ($k_r \approx 0.9832$), it results that: $\rho_f'(r_i) = 0.3273 \times 1.486 = 0.48636 \times 10^{17}$ kg/m^3.

-For the case $r_i = 0.45$ fm, ($d_i^0 = 0.9$ fm), we have $P_{si}(r_i^0) = k_1' \cdot P_{si}^0 = 0.021 P_{si}^0$,
and by Eq.(10) it results similarly:

$\rho_f(a_i) \approx k_r^0\rho_\mu(d_i^0)/(1\text{-} k_1') = 1.474 \times 0.9832/(1\text{-}0.021) = k_{2p}\rho_\mu(d_i^0)$; ($k_{2p} = 1.0043$) and:

$\rho_f'(r_i^0) = k_1'\rho_f(a_i) = 0.021 \times 1.486 \times 10^{17} = 0.0312 \times 10^{17}$ kg/m^3, ($r_i = r_i^0 \approx 0.45$ fm).

So, the condition: $P_{si}(r_i) << P_{si}^0(a_i)$, (maximal nuclear force), is fulfilled for $d_i = d_i^0$ and it is explained by the current quark's vorticity, in accordance with the explanatory model, this result being in concordance with the (multi)vortical nucleon model of CGT in the next way:

In CGT, the phenomenon of preons' current mass increasing with the particle's mass is explained by the fact that the force $F_v = -\nabla V_\Gamma$ given by the total vortical field of the N^e quasielectrons forming z^0-preons (included into the quark's kernel) retains the inertial masses of internal photons inside the quark's kerneloid by a force of static quantum pressure gradient generated conform to the Bernoulli's law, by a dynamic quantum pressure (Eq. (1), which increases proportional to the number of z^0-preons, i.e. proportional to the quark's mass:

$$F_v(r) = -\nabla V_\Gamma = -\nabla N^e \cdot V_\Gamma^e(r); \quad (V_\Gamma^e = -\tfrac{1}{2}\upsilon_f\rho_s c^2) \qquad (11)$$

(υ_f –the volume of the photon's kerneloid, containing its inertial mass; $\frac{1}{2}(\rho_s c^2)_r$ –the dynamic etherono-quantonic pressure in the Γ^e –vortex of a bound quasielectron at r -distance).

The explanation of the fact that the static pressure P_{si} of the bag's surface is decreased (and not increased) at the half of d_i -interdistance between nucleons (in A-point) is the fact that the superposition of the vortical fields $\Sigma_{n1}(\Gamma^e)$ and $\Sigma_{n2}(\Gamma^e)$ of the interacting nucleons increases the total dynamic pressure $P_{dt}(r_i) = \Sigma P_{di}(r_i)$ reducing the static pressure not only by the Bernoulli's law but also by the decreasing of the dynamic pressure's gradient, $\nabla P_{dt}(r_i)$ which generate the vortical attraction force $F_v(r)$ acting over internal „naked" photons, reducing their static pressure on the nucleon's kernel of interaction radius a_i.

It is possible to explain the conclusion $P_{si}(r_i)_A \to 0$ by the Bernoulli's law (8) in the next way:
-Considering- in a simplified model- that only the vortical field of V_Γ^e characterized by etherono-quantonic vortices containing small photons ($m_f \to h1/c^2$) and by $\eta^* = 0.8$ fm generate the quantum static pressure variation at the nucleons' interaction, (i.e. considering that the vorticity generated by heavier photons is compensated by the quantonic static pressure P_{sh}), then for a free nucleon, on the vortex-line $l_{ai} = 2\pi a_i$, by the Bernoulli's law for the case: $r_i = a_i$ characterized by a maximal static pressure of photons $P_{si}(a_i) = \rho_f(a_i)c^2$ we have:

$$P_{si}(a_i) + P_{di}(a_i) = \rho_f(a_i)c^2 + \tfrac{1}{2}\rho_\mu(a_i)c^2 \approx [k_{1p}\rho_\mu(d_i) + \tfrac{1}{2}\rho_\mu(a_i)]c^2 = P_s^*(a_i) \le \rho_n(a_i)c^2 \qquad (12)$$

When another nucleon (2_a) is approached at an interdistance $d_i' = 2a_i \approx 1.2$ fm, the dynamic quantum pressure of vortexed quantons in A-point (at $r_i = a_i$) is increased to a double value and from the Bernoulli's law (Eq.(8)) it results that between the nucleonic kernels we have:

$$P_s'(a_i) + P_d'(a_i) = [\rho_f'(a_i) + 2k_a(\tfrac{1}{2}\rho_\mu(a_i))]c^2 \approx [k_{1p}\rho_\mu(d_i) + \tfrac{1}{2}\rho_\mu(a_i)]c^2 \le 0.5\rho_n^0 c^2 \qquad (13)$$

where $k_a < 1$ is a vorticity attenuation factor which take into account the fact the interference of the vortical fields of the two interacting nucleons. It results from Eq. (13) that:

$$\rho_f'(a_i) \approx \rho_f(a_i) - \tfrac{1}{2}\rho_\mu(a_i)[2k_a - 1] = 0.486\text{x}10^{17}\ \text{kg/m}^3 \qquad (14)$$

resulting that: $k_a = 0.966$.

-For $r_i = r_i^0 = 0.45$ fm, similarly, for a free nucleon, on the vortex-line $l_{ri}^0 = 2\pi r_i^0$ we have:

$$P_{si}(r_i^0) + P_{di}(r_i^0) = \rho_f(r_i^0)c^2 + \tfrac{1}{2}\rho_\mu(r_i^0)c^2 \approx [k_{3p}\rho_\mu(d_i^0) + \tfrac{1}{2}\rho_\mu(r_i^0)]c^2 = P_s^*(r_i^0) \qquad (15)$$

-When the nucleonic kernels enters in mechanic contact, at $d_i = d_i^0 = 2r_i^0 = 0.9$ fm, similarly to Eq. (13), it results that between nucleons, in A'-point (at $r = r_i^0$) we have :

$$P_{si}'(r_i^0) + P_{di}'(r_i^0) = [\rho_f'(r_i^0) + 2k_a \tfrac{1}{2}\rho_\mu(r_p^0)]c^2 \approx [\rho_f(a_i)\cdot e^{-\left(\frac{r_i^0 - a_i}{\delta}\right)^2} + \tfrac{1}{2}\rho_\mu(r_i^0)]c^2 ;$$
$$\Rightarrow \rho_f'(r_i^0) \approx \rho_f(a_i)\cdot e^{-\left(\frac{r_i^0 - a_i}{\delta}\right)^2} - \tfrac{1}{2}\rho_\mu(r_i^0)[2k_a - 1] = k_2\rho_f(a_i); \qquad (k_2 = 0.021) \qquad (16)$$

Because from Eq. (10) it results that: $\rho_f'(r_i^0) \approx 0.0312\text{x}10^{17}$ kg/m^3, by Eq. (16) it results:

$$-\left(\frac{r_i^0 - a_i}{\delta}\right)^2 = \ln\{[\rho_f'(r_i^0) + \tfrac{1}{2}\rho_\mu(r_i^0)(2k_a - 1)]/\rho_f(a_i)\}, \Rightarrow \delta = 0.35 \ \text{fm} \qquad (17)$$

It is observed that the new obtained value for the variation constant δ(0.35 fm) is enough close to the previously approximated value: $\delta = \sqrt{2}(a_i - r_M) = 0.3327$ fm. So, we can consider this last value of δ as acceptable for our simplified theoretic model and it explains unitary not only the maintaining of the current quarks inside the nucleon's ‚bag' of radius $a_i = 0.6$ fm, but also the scalar nuclear interaction between nucleons.
The rest mass of the constituent quark, given in CGT by „naked" photons, is retained by the vortical field of the current quarks according to Eq. (11)

5. The bag's constant variation with the particle's intrinsic temperature

5.1. The total potential of interaction between nucleons and between composite quarks

The conclusion of nuclear physics that at distances less than $d_r \approx 0.7$ fm the nuclear force becomes repulsive, corresponds in CGT to the conclusion that the current u/d quark has a thin repulsive shell $\delta_q \approx (0.09\div0.1$ fm) generated similar to the case of the nucleon's kerneloid and that the radius $r_q \approx 0.2$ fm of a spherical current u/d-quark characterizes a dilated current quark's volume $\upsilon_q^j \approx 0.0335$ fm^3 corresponding to the nucleon's temperature $T_n^j \approx 1$MeV/k_B, ($1.16\text{x}10^{10}$ K) and to an its intrinsic temperature:
$T_i^q = T_z^j \approx (m_z/M_n)T_n^j \approx (m_u/18M_n)T_n^j = (7.5/18\text{x}938)\text{x}10^{10} = 0.51\text{x}10^7$ K; (m_z ; m_u –mass of z^0-preon's kerneloid and of current u-quark, considered in CGT; M_n –the nucleon's mass), the volume υ_q^0 of 0K being given by a compact hexagonal form of 18 z^0-preons (2x7+4) whose cold volume υ_z^0 is given by 42 electronic kerneloids with radius $r_i^e \approx 10^{-17}$ m- corresponding to an experimentally obtained value reported by Milloni [12], it resulting of radius $\approx r_q^0 = 0.09$

fm and a high $h_q^0 = 0.36$ fm, ($\upsilon_q^0 = 0.0091$ fm^3), corresponding to a current u/d-quark contracted more radially than axially.

In this case, the current quark's volume υ_q^j is deformable but its internal pressure: $P_i^q = n_z^0 k_B T_z$ opposes a resistance force $F_{qr} = -\nabla V_{qr}$ which explains why an interaction between two nucleons (whose kernel's radius: (0.44÷0.45) fm is given by the diameter of a dilated current u/d –quark, ~0.4 fm, and a small quark's vibration) is repulsive at $d_r \approx 0.7$ fm.

We want see if we can obtain a total potential of interaction between nucleons and between composite quarks using the previous conclusions of CGT.

In the S.M. it is also known the Sombrero -type potential, which explains the process of spontaneous symmetry breaking considered for the explaining of particles' forming from quantum vacuum [13]:

$$V(\phi) = \mu^2|\phi|^2 + \lambda|\phi|^4 \ ; \quad \phi = |\phi|\cdot e^{i\theta} \ ; \quad dV(\phi)/d\phi = 0, \Rightarrow |\phi|_i^2 = -\mu^2/2\lambda = \upsilon^2 \qquad (19)$$

In CGT, this genesic potential corresponds as form to a total potential of the interaction by the field of a vortical particle with the kernel (kerneloid) of another particle, the first part corresponding to an attractive potential of the form (1): $V_a = -½\upsilon_p\rho_\mu c^2 = V_a^0 \cdot e^{-r/\eta^*} = \mu^2|\phi|^2$ by taking: $\mu^2 = V_a^0$ and: $|\phi|^2 = \rho_\mu(r)/\rho_\mu^0 = e^{-r/\eta^*}$ and the second part corresponding to a repulsive potential, which by Eq. (19) results of the form: $V_r = \lambda|\phi|^4 = V_r^0 \cdot e^{-2r/\eta^*}$, giving:

$$V_t(r) = V_a + V_r = \mu^2|\phi|^2 + \lambda|\phi|^4 ; \ V_r = V_r^0 \cdot e^{-2r/\eta^*} = V_r^0 \cdot e^{-r/\eta'} = V_r^0 \cdot [\rho_r(r)/\rho_r^0] \ , \qquad (20)$$
$$(\mu^2 = V_a^0; \lambda = V_r^0 = \upsilon_p \cdot \rho_r^0 c^2 \ ; \ \eta' = \eta^*/2; \ [\rho_r(r)/\rho_r^0] = [\rho_\mu(r)/\rho_\mu^0]^2)$$

This repulsive potential (20) corresponds to a static quantum pressure: $P_s = \rho_r(r)c^2$ generated by vibrations of the particle's kernel, (these vibrations generating the partially destroying of photonic vortices inside the particle's kernel, conform to CGT [1, 2]), whose value decreases more quickly than the value of the dynamic pressure $P_d = ½\rho_\mu(r)c^2$ which generates the V_a-potential.

The condition: $dV(r)/dr = 0$ is in fact the condition of equilibrium: $F_t(r) = -\nabla V_t(r) = 0$, i.e:

$$F_t(r) = (-1/\eta^*) V_a^0 \cdot e^{-r/\eta^*} + (-2/\eta^*) V_r^0 \cdot e^{-2r/\eta^*} = 0; \ \Rightarrow |\phi|_i^2 = -\mu^2/2\lambda \qquad (21)$$

retrieving the value resulting from Eq. (19) of $|\phi|_i^2$ which in our case is: $|\phi|_i^2 = \rho_\mu(r_i)/\rho_\mu^0$.

It can be also observed that the Sombrero potential (19) used in the form (20) have similitude with the Morse molecular potential [14]:

$$V_t(r) = D(e^{-2\alpha x} - 2e^{-\alpha x}) \ ; \quad (x = (r-a)/a) \qquad (22a)$$

but transformed in the form

$$V_t(r) = V_r^0(e^{-2\alpha r} - k_a e^{-\alpha r}) \ ; \qquad (\alpha = 1/\eta^*; \ k_a = V_a^0/V_r^0) \qquad (22b)$$

Extrapolating to the case of the nucleon's kernel (kerneloid), i.e.: $\eta^* \approx 0.8$ fm; $V_a^0 \approx 110$MeV, the value of V_r^0 can be obtained by the condition: $F_t(r_i \approx 0.8\text{fm}) = 0$, which gives: $V_r^0 = 149.5$ MeV and: $V_r(0.9fm) = 15.75MeV$ - compared to: $V_a(0.9fm) = 35.7MeV$.

Also, for $r_r = 0.7$ fm, it results: $F_r(r_r) = 64.94 \times 10^2$N; $F_a(r_r) = -57.3 \times 10^2$N –so the conclusion that for $r \leq 0.7$ fm the total force $F_t(r)$ becomes repulsive is verified.

But for $d_i = 2$ fm it results: $V_t(r=2\text{fm}) = (V_a + V_r)_{2fm} = 9.03 - 1 \approx 8$ MeV –value a little lower than the mean binding energy per nucleon in the nuclei with the most strongly bound nucleons, (~ 9 MeV/nucleon), indicating that the repulsive potential has a faster variation with r. In this case, we will try to find a form: $V(\phi) = \mu^2|\phi|^2 + \lambda|\phi|^{2n}$ (n>2) of the total potential V(r), i.e. of the form: $V_r^0 \cdot e^{-nr/\eta^*}$, (n >2). It results that –similar to the case of the Reed's potential [r], the value n = 7 fits satisfactory to the experimental data, resulting that:

$$F_t(r_i) = (-1/\eta^*) V_a^0 \cdot e^{-r/\eta^*} + (-n/\eta^*) V_r^0 \cdot e^{-nr/\eta^*} = 0; \Rightarrow V_r^0 = (-V_a^0/n)\, e^{(n-1)r/\eta^*} \qquad (23)$$

Because the equality (23) is satisfied for $r_i \approx 0.7$ fm, with n = 7, $V_a^0 = 110$ MeV and $\eta^* = 0.8$ fm resulting that: $V_r^0 = 2994.6$ MeV. The maximal force $F_t^M(r)$ corresponds to: d $F_t(r)/dr = 0$ giving by Eq. (23):

$$dF_t(r)/dr = 0, \Rightarrow (1/\eta^*)^2 V_a^0 \cdot e^{-r/\eta^*} + (n/\eta^*)^2 V_r^0 \cdot e^{-nr/\eta^*} = 0; \quad n^2 V_r^0/V_a^0 = e^{(n-1)r/\eta^*} \qquad (24)$$

Eq. (24) being verified by the value: $r = r_M = 0.96$ fm (close to the value: 0.9 fm, experimentally determined), the value of the resulting potential $V_r(r)$ being negligible to interdistances r > 1 fm.

A nucleon having its kinetic energy: $E_d = 175$ MeV corresponding –in Galilean relativity, to the temperature of nucleon's transforming into quarks ($T_d \approx 2\text{x}10^{12}$ K), will be stopped by the potential $V_r(r)$ to an interdistance $r_s = 0.324$ fm given by: $E_d = V_r^0 \cdot e^{-7r/\eta^*}$, corresponding to a maximally comprimed current u/d-quark, so – as in case of V_a^0, the obtained value of V_r^0 is only mathematical.

A better fit with the value $r_M = 0.9$ fm experimentally verified, results by a repulsive potential with the form used by Reid's formula [15]: $V_r(r) = V_r^0 \cdot e^{-7r/\eta^*}/(r/\eta^*)$ with $V_r^0 = 2620$ MeV, giving $r_M = 0.93$ fm and $r_s = 0.39$ fm.

At interdistances $r \geq 4r_q \approx 0.8$ fm the value of the repulsive potential is explained by a repulsive pseudo-charge q_s of current quarks and of nucleon's kerneloid, generated by vortically attracted and vibrated ‚naked' photons at the current quark's surface and at the nucleon's kerneloid, which generates the bag's pressure P_{is}^0 of the bag's constant B –in CGT, with the difference that the repulsive pseudo-charge q_s which explains the repulsive potential $V_r(r) = V_r^0 \cdot e^{-7r/\eta^*}$ is generated by the component $½\rho'_f$ given by naked (light) photons having the speed $v_f \uparrow\uparrow r$ whose radially acting pressure is reduced by the dynamic pressure $P_d = ½\rho_\mu(r)c^2$ of the adjacent nucleon, between the interacting nucleons, with the variation of their static pressure considered as real in the form corresponding to Eq. (3), for the nucleon's free state, in CGT.

A corrected expression of $V_r(r)$ –potential results in this case, by Eq. (23), in the form:

$$V_r(r) = V_r(r_s) = 175 \text{ MeV for } r \leq r_s = 0.324 \text{ fm}; \qquad (25)$$

$$V_r(r) = V_r^0 \cdot e^{-7r/\eta^*}, \ (V_r^0 = 2994.6 \text{ MeV}; \ \eta^* = 0.8 \text{ fm}) \text{ for } r > r_s$$

By similitude with the nucleon's ‚impenetrable' kernel, this $V_r(r)$ -potential can be considered also for composite (heavy) quarks formed as clusters of three light quarks (a pair quark-antiquark and an un-paired quark).

So, the repulsive potential well V_r^0 considered also for interaction between quarks can be written in a form: $V_r^0 = k_r \cdot q_s^2$ with $q_s = \sqrt{(\upsilon_q \cdot P_{si}^0)}$- repulsive pseudo-charge, resulting that the value of this pseudo-charge depends on the value of the associated ‚bag' constant B and on the value of the υ_q –volume of the particle's kerneloid, which- for a composite quark Q with dilated volume $\upsilon_Q(T_q)$, results as sum of apparent volumes $\upsilon_q(T_z)$ of its lighter quarks q, depends on the current quark's mass m_q and on its its intrinsic temperature $T_i^q = T_z$ given by the vibrations of the kerneloids k_z of their z_0 –preons, conform to the dilation' law:

$$\upsilon_Q(T_q) = \upsilon_Q^0(1 + \alpha_Q\Delta T_q) \approx N_q\upsilon_q^0(1 + \alpha_q\Delta T_z) \approx N_z^Q\upsilon_z^0(1 + \alpha_z\Delta T_z) \qquad (26)$$

From (26) it results that: $\alpha_Q = \alpha_q(\Delta T_z/\Delta T_q) \approx \Delta\upsilon_q^a/\upsilon_q^0\Delta T_q$ with T_q –the temperature associated to the q-quarks' vibration.
So, similarly to the case of two interacting nucleons, it can be analysed the case of two current quarks forming a meson – for example, (i.e. the case of a pair quark-antiquark, q- $\bar{q}$).

This result is important for the explaining of the density increasing in case of the neutron stars' collapsing by the forming of quark stars or dense black hole stars- formed when the repulsion force between current quarks and between neutronic kerneloids cannot stop the gravitational collapsing of the initial neutron star, which is progressively cooled, (this cooling reducing the q_q-preudo-charge and the repulsive potential $V_r(r)$.

5.2. The similitude between the quark models of CGT and of S.M.

The conclusion that the bosonic shell of the current quarks is a photonic one, is in concordance with the fact that all charged particles emit photons and with the upper limit for the gluon's mass experimentally determined: 1÷1.3 MeV/c^2 [16] -approximately equal to that of an (e^-e^+) pair.

It is also possible to make a similitude between the S.M.'s quark model, supposing a valence current quark and a shell of qluons conceived as (q- $\bar{q}$)- pairs which interact by the color charge of the paired quarks and which generate an anti-screening effect that increases the strong force over an adjacent current quark, and the CGT's model of quark formed by a kernel of z^0-preons and an un-paired charged quasi-electron that gives its electric charge $e^* = (^2/_3)e$, surrounded by a photonic shell.

Supposing that at a critical temperature $T_c \rightarrow T_d$, (T_c –phase transformation temperature; T_d – the quarks deconfining temperature: ~ $2\text{x}10^{12}$ K) some paired kerneloids of paired quasi-electrons (‚gammons' –in CGT, [10-12]) are released and transferred from the quasicrystalline cluster of its kerneloid in the volume of its photonic shell, then their behavior will be relative similar to that of the polarised gluons in S.M., with the difference that these ‚gammons' will interact by electric and magnetic interactions, (having the tendency to form clusters with 8 quasielectrons at T →0K) but being maintained inside the constituent quark's volume by the force generated by a potential of the form (1), i.e. by the total vortical field of the current quark, (Eq. 16).

After partial deconfining of a current quark, its reconfining at $T < T_c$ could generate a quasi-crystal or amorphous state- similar to the so-named ‚glasma' in the S.M., [48; 49], with the difference that this state is considered in S.M. as specific to a saturation state in high energy hadronic collisions and not to a low temperature quarcic state.

For the S.M.'s quark model, it results the possibility to explain as in CGT the forming of heavy quarks as tri-quark clusters of lighter quarks having a current mass higher than the sum of masses corresponding to the lighter current quarks of its structure, by the addition of a part of gluons of its gluonic shell, i.e.- by an amorphous of quasi-liquid state of its current mass.

5.3. Drop model of ‚melted' current quark

From the previous similitude and taking into account the ‚bag' model specific to CGT, it results the possibility to describe a current quark ‚melted' at high impact energy $E_k \to E_d$ corresponding to a temperature close to the u/d- quarks' deconfining temperature $T_d = E_d/k_B \approx 2x10^{12}$ K, by a drop model of composite current quark, having an internal temperature $T_i^Q = T_q$ - given by the kerneloids of its preonic light quarks q, or $T_i^q = T_z$ - given by the kerneloids of its z^0-preons (which generate an internal pressure $P_z = n_z^0 k_B T_z$), equilibrated by the energy given by a superficial tension $\sigma_q = F_z(y)/2l_v$ given by $P_e(B) = P_{si}^0(a_i)$ –for $T_i = T_q^j = T_n^j(m_q/M_p) = (1MeV/k_b)(7.5/938) = 9.27x10^7$ K:

$$\Delta P \cdot dV(r_Q) = \sigma_q \cdot S(r_Q); \quad \Rightarrow \quad P_i = \frac{2\sigma_Q}{r_Q} = P_e(B); \qquad (\sigma_Q = \frac{F_n(y)}{2l_y}) \tag{27}$$

When the volume $\upsilon_Q(r_Q;T_q)$ of the composite current quark Q is dilated or contracted, because the quark's mass remain the same we can approximate that the value: $F = 4\pi r_Q^2 P_e(B)$ remains quasi-constant, for a composite quark $Q_u(u\ \bar{u}\ d)$ or $Q_d(d\ \bar{d}\ u)$ resulting that:

$F = 4\pi r_Q^2 P_e(T_q) = 4\pi a_i^2 P_{si}^0(T_q^j)$ and: $\sigma_Q = ½ P_{si}^0 a_i^2/r_Q$.

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